# SUMMARY REPORT

OF THE

# GEOLOGICAL SURVEY BRANCH

OF THE

# DEPARTMENT OF MINES

FOR THE CALENDAR YEAR

# 1909

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*To His Excellency the Right Honourable Sir Albert Henry George, Earl Grey, Viscount Howick, Baron Grey of Howick, a Baronet, G.C.M.G., &c., &c., &c., Governor General of Canada.*

MAY IT PLEASE YOUR EXCELLENCY,—

The undersigned has the honour to lay before Your Excellency, in compliance with 6-7 Edward VII., chapter 29, section 18, the Summary Report of the operations of the Geological Survey during the calendar year 1909.

WILLIAM TEMPLEMAN,
*Minister of Mines.*

To the Hon. WILLIAM TEMPLEMAN, M.P.,
Minister of Mines,
Ottawa.

SIR,—I have the honour to transmit, herewith, my summary report of the operations of the Geological Survey for the calendar year 1909: which includes the reports of the various officials on the work accomplished by them.

I have the honour to be, Sir,
Your obedient servant,

(Signed) R. W. BROCK,
*Director Geological Survey.*

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# SUMMARY REPORT

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## FOR THE CALENDAR YEAR 1909.

To the Hon. William Templeman, M.P.,
Minister of Mines.

Sir,—I have the honour to submit, herewith, a summary report on the operations of the Geological Survey for the calendar year 1909.

The Survey lost through death two of the oldest and most widely known members of its staff, Dr. J. F. Whiteaves, Assistant Director, Palæontologist and Zoologist, and Mr. Hugh Fletcher, geologist.

Dr. Whiteaves had been connected with the Survey since 1875, during which time he had charge of the Palæontological division. He accomplished a vast amount of work, as shown by the voluminous literature to his credit published by the Survey. He was one of the last of the old corps of palæontologists that included brilliant scientists of almost every civilized country, and that during the latter half of the nineteenth century did so much to advance the sciences of geology and palæontology.

Mr. Fletcher joined the staff in 1872, and since 1875 has had charge of geological investigations in Nova Scotia. For more than thirty years he has been an authority on Nova Scotia geology. His work was marked by painstaking care and accuracy. His industry is shown by the number of maps credited to him, nine small scale and sixty-five of our standard maps of the Province having been made by him, and a number of others are now being completed. He was greatly esteemed both on account of his geological knowledge and charm of personality, especially in Nova Scotia, where he was best known.

The present organization of the Survey is as under:—

*Administrative and General.*—1 director; 1 secretary; 1 resident caretaker; 2 publication clerks; 2 stenographers; 1 messenger; 1 nightwatch; 3 firewatches; 1 cabinetmaker and carpenter.

*Geological Division.*—11 geologists; 6 assistant geologists; 1 compiler.

*Palæontological Division.*—1 vertebrate palæontologist; 1 invertebrate palæontologist; 1 assistant palæontologist.

*Mineralogical Division.*—1 mineralogist and curator; 1 assistant curator; 1 collector and distributor.

*Topographical Division.*—1 topographer; 3 assistant topographers; 1 custodian of instruments.

*Natural History Division.*—1 botanist and naturalist; 1 assistant botanist and naturalist; 1 stenographer; 2 taxidermists.

*Draughting Division.*—1 geographer and chief draughtsman; 11 draughtsmen; 1 clerk.

*Library.*—1 librarian; 1 assistant.

One geologist, a geological compiler, two draughtsmen, and a library assistant were appointed during the year.

This staff is too weak, numerically, to begin to cope with even the most pressing work in a country that is so extensive as Canada and that is so rapidly being opened up. To overcome this in some degree, outside assistance is engaged for geological, topographical, and ethnological field work. Foreign specialists, especially those of the United States, give invaluable aid in determining special collections of natural history or palæontological material.

But the official staff must be strengthened to meet the growing needs, especially in those divisions that are relatively weakest, such as the topographical and palæontological. Since Dr. Whiteaves' death all the palæontological work has devolved upon Mr. Lambe. The geological division, which may be taken as representing the effective 'fighting strength' of the Survey, must, of course, be added to; at present it is scarcely larger than that assigned by the United States Geological Survey to work in Alaska alone. Still it is relatively over-large for the topographical division, which should be strong enough to keep it supplied with base maps. Until the topographical division has been brought up to such a strength, thoroughly satisfactory work can not be done. To do this is not merely a matter of funds; in fact, the greatest difficulty is in securing the right type of qualified men. A number of young men are now in training for both the topographical and geological divisions. When the Survey is installed in the new Museum building, additional museum assistants will be necessary, and in particular a trained, scientific ethnologist must be added to the staff to take charge of the Hall of Ethnology and Archæology.

## FIELD WORK.

The distribution of field parties during the past season was as follows:—

### Yukon and Mackenzie.

Mr. D. D. Cairnes spent the season on the Wheaton river, near Whitehorse, Yukon Territory. Mr. Cairnes discovered some coal seams in this district which may prove important. The district is extensively mineralized. Mr. Cairnes also visited certain

quartz veins east of Whitehorse, and some copper deposits recently found on Williams and Merritt creeks near Yukon Crossing.

Mr. V. S. Stefansson, who is on the *Arctic* near the mouth of the Mackenzie river, is continuing his researches, and will again winter in the north.

## British Columbia.

Mr. W. W. Leach was engaged along the Grand Trunk Pacific near Hazelton. Mr. Leach reports that the most important developments of the year are the opening up of several very promising silver-lead veins.

Mr. R. G. McConnell completed his geological survey of Texada island, and made a brief reconnaissance survey of the principal mineral districts of Moresby island, Queen Charlotte group. The ore bodies so far discovered on the latter warrant further and more energetic development.

Mr. F. H. MacLaren completed the topographical map of Texada island, and several large scale maps of the chief mining camps.

Mr. C. H. Clapp continued his geological reconnaissance in the southern part of Vancouver island. The season was spent on the southwest end between Point Nopoint and Alberni canal.

Mr. J. A. Allan, under Mr. Clapp's supervision, spent the season studying the metamorphic rocks between Cowichan harbour and Ladysmith, on Vancouver island.

Mr. R. H. Chapman was in charge of several parties engaged in topographic mapping on the south end of Vancouver island.

Mr. John Macoun and Mr. C. H. Young were again on Vancouver island completing their collection of its flora and fauna for the Museum. Mr. Wm. Spreadborough acted as assistant.

Mr. Chas. Camsell continued his geological survey of the Tulameen district. This little known district is remarkable for the variety of economic minerals found within its borders. Platinum, gold, silver, copper, lead, iron, chromite, molybdenite, asbestos, and coal are reported.

Mr. R. L. Reinecke completed the topographic map of the Tulameen district, and commenced a topographical and geological survey of the Beaverdell district, West Fork of the Kettle river, which, since 1899, has been an important prospective mining camp. Although unprovided with transportation facilities, considerable ore shipments have been made.

Mr. G. Malloch was engaged in reconnaissance work along the line of the Grand Trunk Pacific railway between Tête Jaune Cache and Fort George.

Mr. W. H. Boyd was in charge of a topographical party, mapping the Slocan district on a large scale.

Mr. O. E. Leroy was engaged in detailed economic geological work in the Slocan. This work, it is hoped, will have some influence in bringing about the reopening of properties, now idle, that should be producing, and in reviving interest in what was, a few years ago, the most important silver and lead district in Canada.

Mr. S. J. Schofield was engaged in topographic and geological work in East Kootenay, principally north of the Crows Nest Pass railway, and on the St. Mary

river. Copper and lead-zinc ores are found. The exploitation of the former up to the present has been attended with small success, but the lead zinc prospects are more promising.

### Alberta.

Mr. D. B. Dowling, who discovered the Bighorn coal basin in 1906, extended his explorations northward this season. A new coal basin was found, reaching north from the Saskatchewan to the sources of McLeod river, a distance of over sixty miles. A coal-bearing horizon of a smaller area, east of the Bighorn range, was also located.

### Saskatchewan.

Mr. W. McInnes explored the country in the neighbourhood of Lac La Ronge, including Nemeiben lake to the west, Wapawekka lake to the east, and a portion of Churchill river to the north, for the purpose of ascertaining the value of the reported mineral discoveries in this district. Unfortunately he was not able to report favourably upon the metallic minerals. The non-metallic deposits of lignite, glass sand, and magnesian limestone are, however, of economic interest.

### Ontario.

Mr. W. Malcolm spent a few weeks collecting data in the oil fields of southwestern Ontario.

Mr. W. A. Johnston continued his geological and topographical work in the Lake Simcoe region. Mr. Owen O'Sullivan assisted in the topographic work by surveying control lines.

Mr. T. B. Taylor, who was engaged last year in extending his studies of the superficial geology of the Great Lakes region from the United States into Ontario, continued his work in Ontario during a portion of the past season.

Mr. W. H. Collins extended his surveys in northeastern Ontario, making reconnaissance surveys in the neighbourhood of Florence lake, and the district about Gowganda. Messrs. Burroughs and Rogers, of the Bureau of Mines, Ontario, made a detailed survey of the six townships centreing about Gowganda lake, viz., Van Hise, Haultain, Milner, Nicol, Leith, and Charters. Mr. Collins' task was to secure the information concerning the outlying regions necessary to complete a map covering about 900 square miles, which includes Elk, Silver, Miller, and Gowganda lakes, and Maple mountain. With the area covered by the Bureau of Mines, this has been accomplished.

### Quebec.

Mr. Morley E. Wilson was engaged in continuing his surveys north of Lake Timiskaming, near the interprovincial boundary line, in Ontario and Quebec. The area covered includes Larder lake and Opasatika lake.

Mr. J. A. Dresser resumed his investigations in the asbestos regions of Quebec. Some interesting and important observations regarding the distribution of asbestos in the serpentines will be found in his report on the season's operations.

### Maritime Provinces.

Mr. R. W. Ells continued his investigation of the oil-shales of eastern Canada. Gaspé (Quebec), New Brunswick, and Nova Scotia shales were examined as to extent and economic value.

Mr. G. A. Young was occupied in topographical and geological surveys in the district about and south of Bathurst, N.B. This was a continuation of the work of last season.

Mr. L. Lambe and Mr. W. J. Wilson each spent a few weeks in collecting palæontological material from southern New Brunswick.

Mr. Hugh Fletcher returned to his investigations in the northern portion of Cumberland county, N.S., which were carried on until the middle of September, when he was seized with an illness that proved fatal. Mr. R. W. Ells has compiled a report from his journal.

Mr. E. R. Faribault continued his geological mapping in the southern portion of Lunenburg county. In December he returned to Nova Scotia to examine recently found tungsten veins near Moose river.

Dr. H. Ries spent the summer investigating the clays and shales of Nova Scotia, as to their extent and economic value.

Mr. J. Keele co-operated with Dr. Ries in these investigations.

### Boring.

The boring operations on Prince Edward Island commenced last year were continued during the present year.

## SPECIAL FEATURES OF THE WORK.

The work of the Survey is not spectacular. It is close, tedious mapping, working out geological structures, investigating economic possibilities, and in other ways securing and making known the geological information required by the prospector and miner, to enable him to intelligently direct his energy in locating and opening up deposits of economic minerals. This year, as last, almost all of the work undertaken by the Survey has been along strictly economic lines.

It must not be thought that the geologists of the Survey are engaged in prospecting. Such is not the business of the Survey. Prospecting is entirely different work, and should, and has to be left to the private individual. The government geologist may recognize and direct attention to mineralized districts that afford promising ground for prospecting, and furnish information regarding the geological conditions, and mode of occurrence of minerals, that will form serviceable guides to the prospector; but only rarely can a geologist, engaged in his legitimate work, actually discover important bodies of economic minerals. His work in unprospected areas must be too general for this, and where detailed work is undertaken, it is in mining camps where prospecting has already been done. Yet important discoveries are to be credited to officials of the Survey. During the past season it will be noted that Mr. Cairnes discovered a new occurrence of coal in the Whitehorse district, and Mr. Dowling found a new and apparently important coal basin in Alberta.

But quite as valuable are the normal results of the investigations of the field officers. For instance, Mr. LeRoy's work in the Slocan will stimulate mining in this district, and assist in the discovery of new ore bodies; Mr. Dresser has observed facts regarding the occurrence of asbestos that will afford a valuable clue in prospecting for this important mineral.

The scientific investigation of the clays of the Maritime provinces by Dr. H. Ries, Professor of Economic Geology, Cornell University, and Mr. J. Keele, is the beginning of an important series of studies which it is hoped may be extended to cover the settled portions of the whole Dominion. The clay industry of a well developed country forms one of its principal industries, both as regards the value of the output and the number of men employed. In inaugurating this work the Survey was fortunate in securing the services of Dr. Ries, the most experienced authority in America on the subject.

Negative results are, in their way, quite as valuable as positive. All areas do not prove to be promising, and the negative results obtained in such are as important in discouraging the waste of capital and energy, as the positive results in others are in attracting capital and directing its employment.

## COMMITTEES.

The geological and map committees which were formed last year to critically consider reports and maps, and to act as advisory bodies in connexion with matters pertaining thereto, have fully justified their formation, by the results already attained. Much has been accomplished toward improving and standardizing the work done by the Survey. The Geological Committee consists of Messrs. McConnell, McInnes, LeRoy, and Young (Secretary); the Map Committee of Messrs. Dowling, Boyd, Senecal, and Dickison (Secretary). The Director is an ex-officio member of both committees.

A great deal of important work falls upon the members of these committees, and especially upon the secretaries, of such a nature that public credit cannot be given for it. It is, therefore, but fitting that attention should be called to it in this place, and that it should be stated that the improvements to be noticed in the most recent reports and maps are to be attributed to the work of the members of these committees.

## TOPOGRAPHICAL DIVISION.

The most practical and convenient method of presenting known geological facts regarding a district is graphically, by means of maps. For this purpose, if the geology has been done in detail, accurate contoured topographical maps are essential as base maps upon which to lay down the geological data. Topographical maps sufficiently accurate for this purpose are accurate enough for all ordinary engineering uses. Moreover, when a district is being surveyed for one purpose, economy demands that it should be done with such accuracy that the topographical base map will serve, indefinitely, all purposes that a map on such a scale can be used for. Such maps are now being made by the Survey, in so far as is possible with the present topographical staff.

But this staff is yet too small to meet the present requirements of the geologists. To assist the topographer in charge of this division in organizing and in training a corps of topographers, the United States Geological Survey generously loaned the services of one of their topographers, Mr. R. H. Chapman, to the Canadian Geological Survey.

## MUSEUM.

Mr. Broadbent was sent to British Columbia early in the year to collect mineral specimens for the new Museum. These were exhibited at the Alaska-Yukon-Pacific Exhibition in Seattle. While not entered in competition, it was universally conceded that they formed the best and most attractive mineral display at the Exposition.

Valuable collections of natural history, ethnological, and geological material were also acquired during the year.

Special mention may be made of the beautiful collection of sea fauna from Vancouver island, made by Mr. Macoun and his assistants, and skillfully preserved by Mr. Young.

In addition to securing fresh material for the new Museum, progress was made by Mr. R. A. A. Johnston, curator, in preparing the present collections for moving. The ethnological collections were packed up, and the labelling and cataloguing of the palæontological collection are in progress, under the supervision of Mr. Lambe.

## PUBLICATIONS.

To be effective, the information collected and published by the Survey must be placed in the hands of those who will find it useful. Every effort is being made to attain this end. The newspapers are informed of Survey publications by means of bulletins issued from time to time. Those who may wish to keep in touch with the publications of the Survey may have their names placed on the notice list, and they will then be advised as to what is appearing. Individual reports as issued are sent free of cost to Canadians interested in them, upon application to the Director.

The increased demand for publications has necessitated the printing of larger editions. For the convenience of libraries and of authors referring to publications, it has been decided to call the reports 'Memoirs,' and to number these consecutively as Memoir No. 1, Memoir No. 2, etc. Similarly the maps will receive their own consecutive numbers, as Map No. 1 A, etc. This change will come into force the beginning of the new year.

It may be mentioned that the recent maps and those hereafter to be published may be obtained printed on linen for field use. An extra charge of ten cents is made for maps on linen.

## SPECIAL PUBLICATIONS.

The work and publications of the Survey add year by year to the knowledge of the minerals and geology of the country. Important facts are liable to become buried under the accumulating mass of detail, reports get out of print, and the literature becomes too voluminous to be readily accessible. It has, therefore, become important to cor-

relate and compile the information on a particular subject into one handy volume for reference. A beginning has been made in this during the past year. An official has been appointed to devote his whole time to the work. With Mr. Faribault, he has been compiling all the information on the gold-bearing rocks of Nova Scotia. This report will soon be ready for the press. A Descriptive Sketch of the Geology and Economic Minerals of Canada, compiled by the Director and Mr. Young, with the aid of other members of the staff, has just appeared; also a compilation of the information on the coals of the Northwest provinces by Mr. Dowling. Similarly, the Natural History division has issued a Catalogue of Canadian Birds, that brings the information on this subject up to date in a handy and readable form.

Other compilations will be undertaken as rapidly as can be done without interfering with the regular investigations, which cannot be curtailed.

## EDUCATIONAL COLLECTIONS OF ROCKS AND MINERALS.

The number of mineral collections distributed to colleges and high schools during the past year has far exceeded that of any previous one: nearly 23,000 specimens have been sent out.

The materials for these are collected by Mr. A. T. McKinnon, who also prepares and makes up the collections. Great praise is due this official for his industry and interest in the work, and to Mr. R. A. A. Johnston, who has general supervision over it, for the completeness and attractiveness of the collections.

## ETHNOLOGY AND ARCHÆOLOGY.

An investigation of the Esquimo of the Arctic, near the mouth of the Mackenzie, was undertaken last year by Mr. V. Stefansson, under the joint auspices of the American History of Natural History and the Geological Survey, and a preliminary report was published in last year's summary.

Mr. Stefansson is still in the north. Last August he was working eastward, and had reached Cape Bathurst. After studying the Baillie Islanders, he intended to proceed to the Coppermine, and winter there with the Esquimo. The winter of 1910-11, if all goes well, will be spent in Victoria Land. His report for 1909 has not yet reached Ottawa.

When the collections are moved to the new building, a scientific, trained ethnologist will have to be appointed to take charge of the collections in the Ethnological Hall, and to direct work in connexion with ethnological and archæological investigations. As pointed out in last year's summary, this work must be undertaken at once or it will be too late, for the materials will be lost forever, and future generations of Canadians will be unable to obtain reliable data concerning the native races of their country.

It is gratifying to note that public opinion is awakening to the urgency, importance, and value of this work. A strong resolution has been received from the Winnipeg meeting of the British Association, urging that steps should at once be taken in this direction. The Archæological Society of America, which has a strong Canadian department, and the Royal Society of Canada, are also interesting themselves in this

matter, so that the time seems opportune to begin serious and systematic work in Canadian ethnology and archæology. The results obtained will be greatly increased by the friendly co-operation of all who may be interested in these subjects.

## WORK OF THE DIRECTOR.

Routine executive work occupied the greater portion of the year.

In January, I attended the Baltimore meetings of the Geological Society of America, and the American Association for the Advancement of Science. From Baltimore I went to Washington, where a conference of the directors of Federal and State Geological Surveys was held. A few days were spent in visiting the National Museum, and in becoming familiar with the administrative system in force in the United States Geological Survey. Returning, a day was spent in New York, at the American Museum of Natural History, in investigating distinctive features of this Museum.

The March meeting of the Canadian Mining Institute in Montreal was attended, as were various meetings of council held throughout the year.

On June 25, I left for Prince Edward Island, to select a site for the final bore-hole to be drilled by the Department in investigating the coal possibilities of the island. From Prince Edward Island, I crossed to Nova Scotia, intending to visit some of the mines, and to look over interesting geological areas in company with Mr. Fletcher; but owing to illness I was compelled to return to Ottawa.

On being released from the hospital, I left for British Columbia.

### BRITISH COLUMBIA.

On July 27, I reached Victoria, and visited the Geological Survey party at work in this vicinity.

On the 28th, I joined the Hon. William Templeman, Minister of Mines, on an official visit to the mining camps along the west coast of British Columbia and in the Yukon.

As I was under physician's orders to refrain from any physical exertion for three months, I could not visit any point not accessible by conveyance, consequently for many mines in many districts visited, information could not be secured by personal investigation, as will appear from the following notes, but had to be gained through mining men familiar with the district, who kindly furnished specimens and descriptions.

In the immediate neighbourhood of Prince Rupert, the known economic minerals are: clay, near Iroquois, on Skeena river, which burns to a good brick; and limestone, on Smith island, which is being utilized for lime. It is said to be of excellent quality. At Prince Rupert, Lieut. P. C. Musgrave met us with the Hydrographic Survey's steamer *Lillooet*, on which we visited Portland canal and Queen Charlotte islands.

#### Portland Canal.

Portland canal is the most northerly inlet on the Canadian coast, and forms part of the boundary line between British Columbia and Alaska. Its length is a little less

than 60 miles. About 10 miles up, Observatory inlet branches off. At the head of Portland canal, on a flat at the mouth of Bear river, the new mining camp of Stewart is being established. The claims are situated on Bear river and its tributaries, commencing about four miles up from tidewater at Stewart.

In 1899 the first claim (Roosevelt) was staked on Bitter creek, a tributary of Bear river, by a prospector, who had gone into the head of Nass river by way of Portland canal and Bear river. In 1902, Stewart's claim, on American creek, was staked. In 1903, a Deputy Mining Recorder's office was established, and in that and the following year some locations were made. In 1905 and 1906, the principal claims on Glacier creek were staked. In 1906, Mr. H. Carmichael, Provincial Assayer, made a report for the Provincial Mineralogist on this district. He visited it again this summer, and his report[1] describing the best known claims has been issued by the Provincial Bureau of Mines. In 1905, Mr. Fred Wright, while engaged in work for the United States Geological Survey in Alaska, made a geological examination of the upper part of Unuk river, which is in British Columbia, about 40 miles north of Stewart. His report on this section was kindly given to the Canadian Geological Survey, and was published in the Summary Report for 1905. As Bear river appears to belong to the same geological province, this report is of direct interest to miners and prospectors in Stewart.

The country is of the character which has become recognized as typical of southeastern Alaska. The valley occupied by Portland canal and Bear river is about a mile wide, flanked on either side by somewhat precipitous mountains rising to a height of about 5,000 feet, with an occasional peak 1,000 or 2,000 feet higher. The canal is navigable to its head for boats of deep draught. Almost at the head of the canal Salmon river enters from the Alaska side, and between it and Bear river is a mountain ridge which the International Boundary follows for some distance.

Bear river has a gentle slope for the first 10 miles, giving an easy gradient for a road, beyond which it is said to rise more rapidly. Glacier creek enters it from the east about 4 miles from the mouth, and Bitter creek about 8 miles up, while American creek enters from the north, about 12 miles up. The majority of the well known claims are on Glacier creek and American creek.

The camp lies in a metamorphic zone along what is probably the eastern limit of the Coast Range granite. The granite forms a long and relatively narrow belt along and near the coast, extending from the Fraser river to the White River basin in the Yukon, a distance of 1,100 miles. Its width is from 30 to 60 miles. This huge body of granite, known as the Coast Range batholith, was intruded into the preexistent Palæozoic (?) sediments at some time between upper Jurassic and middle Cretaceous. The sediments near the granite contact are metamorphosed, the degree of metamorphism becoming progressively less intense from the granite contact to the outer limit of its effect. Dikes from the granite network the adjacent schists, and inclusions of the sedimentary rocks are numerous in the granite batholith for some distance from the contact, and are also found in isolated patches, which are remnants of the original roof, now mostly removed by erosion, through which the great intrusive

[1] British Columbia Bureau of Mines, Bulletin No. 1, 1909.

mass of granite has been exposed. This batholith, and its effect on the adjacent country rock, has been described in previous reports[1] of the Geological Survey.

As noted by Wright, the metamorphism of the sediments on the two sides of the Coast Range batholith is dissimilar. On the western contact the slates and argillites are changed to phyllites, mica schists, and, in immediate contact with the granite, frequently to gneiss. The strata are intensely folded, and give evidence of having been deeply buried at the time of metamorphism. Farther west from the contact, the rocks were evidently nearer the surface at the time of the intrusion, and these show more typical contact metamorphism and mineralization. The rocks along the inland contact of the granite are less altered; typical schists and gneisses are rarer; the contact line is more clearly defined; the rocks show contact metamorphism, and near the contact are often heavily mineralized with sulphides. The distinction between deep-seated metamorphism and contact metamorphism has here great economic importance, for in the former, conditions preclude, as a rule, the formation of ore bodies, while in the latter they frequently favour it.

The most promising rocks to prospect then, are those showing contact metamorphism, and in northern British Columbia, at least, the inland border of the granite is most likely to present this phenomenon, though it also occurs at a number of points along the coastal border. It must be understood that when the contact of the granite is recommended as a point to prospect, the immediate contact is not specially meant, but rather the bordering zone influenced by the intrusion.

Throughout its entire length, wherever the invaded, contact-metamorphosed rocks are exposed along the borders of the Coast Range batholith or occur as large inclusions in it, they will probably be found attractive to the prospector. Such areas are found in the Bear River camp, in the Unuk River district, 40 miles north, and probably in the country between. The geological examination of this field will probably show that the ore bodies owe their origin to the intrusion of the granite.

As it was not possible to visit the claims, little can be said about them. Two classes of ore were exhibited at Stewart: quartzose ore, carrying silver, gold, and lead values, and a pyritic copper-gold ore. The persistence of the veins is noted by all, a succession of claims being located on what is said to be the same vein, traceable throughout. The quartzose ore contains galena, sometimes blende, and silver minerals such as argentite, and native silver. Pyrite is sometimes plentiful. The copper ore consists essentially of pyrite and chalcopyrite.

The Portland Canal Mining Company, on Glacier creek, operating on a vein carrying gold-silver-lead values, has done the greatest amount of work. This is the first Company to put in an aerial tram, and concentrator. The latter will have a capacity of about 50 tons per day.

The Stewart Mining and Development Company ranks next in development work. The ore is somewhat similar.

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[1] Dawson, G. M.—The Yukon Dist., Vol. III, Part I. B., 1887-8, and Report on an Expedition from Port Simpson to Edmonton, 1879-80 B.

Wright, F. E.—The Unuk River Mining Region, Summary Report, 1905.

LeRoy, O. E.—Preliminary Report on a Portion of the Main Coast of British Columbia, Nanaimo and New Westminster Districts, Geol. Surv. Publication 996.

Bancroft, J. A.—Powell River to Kingcome Inlet, Summary Report, 1907.

Graham, R. P. D.—Geology of the Coast from Kingcome Inlet to Dean Channel. Summary Report, 1908.

The ore of the Red Cliff, on American creek, is a copper-gold one. Specimens from it look very promising, and the body is said to be large. A compressor plant is to be installed at this property.

Other properties well spoken of include the American Girl group and Montrose, on American creek; Pasco and Independence, and Tyee, on Bear river; and the Little Wonder, Lake View, O.K., Fraction, Jumbo, Apex, Cook and Dobson, and Matheson claims on Glacier creek.

Wharves are to be constructed, and arrangements have been made by men interested in Mackenzie, Mann & Company, Limited, and in the Canadian Northern Railway Company, to build the 'Portland Canal Short Line railway' from Portland canal up Bear river for a distance of 15 miles. Construction will be started as soon as the snow leaves in the spring, and it is expected that the road will be in operation during the summer. These gentlemen are also directly interested in mining in the district, having bonded some properties on Bear river.

The Hidden Creek Copper Company mine at Goose bay, Observatory inlet, is being actively developed. It is reported to have large bodies of pyrite and chalcopyrite, carrying 3 per cent to 6 per cent copper, with $1 to $3 in gold and silver. An 8 drill compressor, driven by water-power, has been installed, and plans have been made for a tram and electric railway for transporting the ore to tidewater.

## Queen Charlotte Islands.

Returning to Prince Rupert from Stewart, we proceeded to Queen Charlotte islands, stopping at Ikeda bay, Collison bay, Jedway, Lockeport, Skidegate, and Queen Charlotte. For a description of the ore deposits, the reader is referred to Mr. McConnell's report on page 72.

Although the occurrence of iron, copper, and coal on Queen Charlotte islands has been widely known since the publication of Dawson's report[1] in 1878, their isolated position has prevented interest being taken in the islands. With the building of the Grand Trunk Pacific railway, and the founding of Prince Rupert, conditions are changed. The islands are now easily accessible, and will share in the attention which will be devoted to the development of the northern coast of British Columbia. The coal measures of Graham island, reported upon by Dawson, and later by Ells,[2] have remained undeveloped, but this summer were being tested by prospective purchasers. If the tests are satisfactory, a large coal industry is assured, for the measures are admirably situated to supply the northern trade, which will soon be important.

Little development of a decisive character has yet been done on the ores, but the Ikeda mine has demonstrated that at one point, at least, mineral is concentrated in commercial ore bodies. At Klunkwoi bay chalcopyrite and bornite are disseminated throughout a diabase rock over wide areas, the copper in certain areas running ½ per cent to perhaps, in places, 2 per cent, according to McConnell's report. It would seem worth while to try concentration on this material.

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1 Annual Report of the Geological Survey, 1878-9. Report on Queen Charlotte islands. G. M. Dawson.

2 Graham Island Coal Fields. R. W. Ells, Vol. XVI, 1904, Geological Survey Reports.

## Atlin District.

We returned to Port Essington and Prince Rupert, and left the latter on August 9 for Atlin, where some large scale operations with the aid of machinery are in progress. Here we visited Pine and Spruce creeks. On Pine creek, hydraulic mining is being done, and a dredge is under construction. At Discovery, Mr. Refener is operating three pits, each with its battery of monitors. The monitors are used for piling the tailings, as well as for cutting down the banks and feeding the sluice boxes. The yellow, gold-bearing gravels underlie a hard, barren, bluish, glacial boulder-clay, 30 to 40 feet thick in places. This adds to the difficulty of hydraulicing, as its hardness necessitates bulldozing the blocks into which it breaks from the faces. Dynamite is also used to some extent to bring down the banks.

On Spruce creek, individual miners are working bench claims. Most of these are operated on 'lays,' the lessee paying a royalty of 20 per cent or upwards to the owners. Inclines are sunk to bed-rock, and drifts run on the pay gravel. Overshot wooden water wheels are used for hoisting.

The most interesting feature in connexion with mining in the Atlin district is the reported lode discoveries. Unfortunately it was impossible at the time for me to visit them, but from specimens seen and from the descriptions given of the occurrences, they would seem to be promising. They embrace gold, silver, lead, and copper. Taku Arm is staked from near Golden Gate to Jim creek. On the Engineer group, Taku Arm, a wide, gold-bearing ledge occurs, with a second parallel ledge; stringers of quartz rich in gold accompany them. Specimens, said to be from this property, were rich in free gold. Stibnite also occurs. It is reported that samples selected during two months by two men and sent to an assayer netted $1,800. Ore, said to come from Lavdierere claim, Hobo creek, 3 miles from West bay, contained native copper, cuprite, copper glance, chalcopyrite, and magnetite. There is reported to be a large body of low grade ore with high grade streaks. A strike of rich ore on Jim creek, carrying gold, silver, and lead, is reported. On Fourth of July creek there are reported to be solid bodies of argentiferous lead.

Very little prospecting or developing is being done, but this does not necessarily mean that the showings are not as promising as reported, for the high cost of labour and supplies makes it impossible for the ordinary prospector to operate. Mr. J. C. Gwillim, who reported upon this district in 1901,[1] states that 'some of the deposits show sign of strength and probable permanence. The cost of development at present is heavy. Transportation rates added to this make a heavy total for the production of refractory or smelting ores. Such ores are found to some extent in this district, more especially to the north of Pine valley, in the actinolite slates, and in one instance in granite, on Crater creek, a tributary of Fourth of July, there are veins of gold-bearing quartz. Some of these deposits are strong, well defined lodes, usually with a gangue of quartz. Sulphides of iron, lead, and copper are present. As far as determined, these are not of high enough value in the precious metals to encourage their development during present conditions of heavy costs. Other deposits of more or less free-milling gold-quartz offer better returns for development. In some cases very rich assays are given.' Gwillim mentions a number of leads examined by him. Since his report many

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1 Annual Report, Geological Survey, Vol. XII, p. 44 B.

new discoveries have been made and the mineralized areas considerably extended, but the 'conditions of heavy costs' remain practically unchanged, and consequently little has been accomplished toward establishing lode mining.

Hydromagnesite, a precipitate from mineral springs, in the vicinity of Atlin, occurs in some quantity. The bed immediately behind the town covers 2 or 3 acres and is several feet thick. It also occurs on a number of other marshy areas in the neighbourhood. These deposits will be of commercial importance.

### Rainy Hollow.

Some interest is being taken in mineral occurrences in the extreme northwestern portion of British Columbia. Very promising specimens of copper-silver-gold ore made up of chalcocite, bornite, and grey copper with a garnetiferous gangue, were exhibited from Rainy Hollow, Klehini river.

## YUKON TERRITORY.

### Carcross.

The most serious attempts to establish lode mining in this northern section of the Dominion are the operations near Carcross, in what has been termed the Conrad district. A recent report by Mr. D. D. Cairnes[1] describes the district and its ores in detail.

In the time at our disposal, we were able to visit only the Venus and adjoining claims on Windy Arm. A small concentrator has been built on the lake shore, connected with the mine, 900 feet above it, by an aerial tram. About 3,000 feet of development work has been done, consisting principally of a cross-cut tunnel of 600 feet to the vein, and drifts on the vein 500 feet long on each side of the cross-cut. At the ends of the drift are winzes, 150 and 180 feet deep respectively. There is also a raise to the surface. The vein, which is very persistent, varies from 1½ to 4 or 5 feet in width. It is oxidized for about 350 feet below the surface. The oxidized ore is said to run about $10 in gold and $10 in silver. Below the zone of oxidization the gold value is reported to be higher. The vein, angling down toward the lake, may be traced on the surface westward for several claims. An aerial tram connects the Vault to the lake, and another connects the Montana with Conrad. Other claims on which considerable work has been done are the Thistle, Aurora, and Pelly. The Venus and adjoining claims were being operated at the time of our visit.

The chief interest at present in this section centres in the developments at the Big Thing, about five miles from Carcross. I was not able to get out to this property. The vein is said to run from 5 to 16 feet in width, and to carry a quartz-arsenical-gold ore of good grade. A shaft has been sunk at an angle of about 45°, to a reported depth of about 610 feet. It is said to be the intention to tap the vein by a cross-cut tunnel, from the mouth of which an aerial tram will carry the ore to the railway.

[1] 'Report on the Conrad District,' by D. D. Cairnes, Geological Survey. No. 982.

## Whitehorse.

A day was spent at Whitehorse visiting the copper claims in the vicinity. These deposits are of the contact metamorphic type, like the Boundary Creek and Texada Island deposits. They have been described by Mr. R. G. McConnell in a recently published report.[1]

Concerning the three best developed iron ore bodies, Mr. McConnell estimates the tonnages that may be considered assured as follows:—

### PUEBLO.

'The Pueblo ore body consists of an impure mass of hematite, 300 feet in length, with a maximum width of 170 feet. The surface section measures approximately 33,000 square feet. The ore body has been proven to a depth of 100 feet, and at 70 feet a drift of 120 feet failed to cross the lode.

'Assuming that the ore body carries its surface size down to the bottom of the shaft, it would contain 3,300,000 cubic feet of ore above that level. The weight per cubic foot is not definitely known, as the hematite is intermixed with various impurities such as garnet, epidote, quartz, calcite, etc.; but probably averages about 8 cubic feet per ton. This would give a tonnage of 412,500 above the 100 foot level. It is probable that the lode extends some distance below the 100 foot level, and a considerable additional tonnage might safely be added.

'Copper contents probably average 3 per cent. Gold and silver values are small, about $1.'

### BEST CHANCE.

'The ore body is a mass of magnetite, 360 feet long with a maximum width of 65 feet. The surface section measures approximately 13,120 square feet.

'The workings are shallow, and have not proved the deposit to a greater depth than 35 feet. In addition to this the lode projects 15 to 20 feet above the surface. A total depth of 50 feet represents the proved portion of the lode at present. With a depth of 50 feet the lode contains 656,000 cubic feet of magnetite, weighing, at 8 feet per ton, 82,000 tons.

'The grade of the ore in copper is about 3 per cent. The gold and silver values are small.

'The probable tonnage is at least double of that given.'

### ARCTIC CHIEF.

'The Arctic Chief ore body on the main level, 65 feet below the surface, has a length of 190 feet and an average width of 30 feet, the section measuring 5,700 square feet. A shaft from the main level proved ore for a further distance of 25 feet, or a total distance of 90 feet. The surface section is on a slope, and part of the ore body has been removed by erosion. Assuming 80 feet as the average depth of the lode, the contents measure 456,000 cubic feet, weighing, at 8 feet to the ton, 57,000 tons.

[1] Report on Whitehorse Copper Belt. Geol. Survey, Pub. No. 1050.

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| 'Average copper contents | 4 per cent. |
| Average gold | $4 per ton. |
| Average silver | 2 ozs. per ton. |

'Numerous smaller iron masses and irregular lenses of bornite-chalcopyrite-ore occur throughout the district.'

It is likely that the ore on the Pueblo will extend below the present workings at least 50 feet, so that 250,000 tons might be considered as probable ore for the Pueblo. This would give over 800,000 tons on these three properties alone. But the ore may extend for a considerable distance below the present shallow workings. The experience elsewhere on deposits of this type has usually been that considerably more ore is recovered than has been estimated from limited development work. These deposits, therefore, appear to be already capable of producing an important tonnage, with promising prospects for future developments.

None of these properties were working at the time of our visit. It is reported that a spur from the railway will be completed to the Pueblo in the spring, and that shipments may then be made. Some prospecting was being carried on in the Wheaton River district a few miles to the south of Whitehorse. Low grade copper ores similar to the Whitehorse deposits were found this year at Williams creek, near Yukon Crossing. Concerning these Wheaton River and the Williams Creek prospects, information will be found on a later page in the summary report of Mr. D. D. Cairnes. The Wheaton River district contains silver, lead, gold, and antimony veins of some promise. Mineralization is widespread. Coal similar to that at Whitehorse and Tantalus was found this summer by Mr. Cairnes on Bush mountain. The Tantalus coal mine is producing.

### Yukon.

Dawson was reached on the night of August 19. The first day was spent in Dawson itself. On August 21, I went 10 miles down the river to see a rock bluff on the east bank which was reported to pan gold. In the afternoon the party visited the dredge operated by Mr. Simpson on Bonanza creek. On August 23, we started to visit the creeks, accompanied by Mr. F. T. Congdon, M.P., and Commissioner Henderson. Mr. Gray, of Dawson, was with the party for a couple of days, and Sheriff Eilbeck for the rest of the time. The district is well supplied with good roads, so that an automobile was used throughout.

We first went up Hunker creek and down Dominion creek to 33 Below, stopping at Peter Rost's, where we witnessed a clean-up. A pan of fine nuggets from new ground on Caribou creek served as an interesting reminder that discoveries of rich ground can still be made. Returning to the summit, the night was spent at the roadhouse. Next morning a stop was made below the Dome to visit the tunnel being run in from Dominion Creek slope, to prospect quartz veins that have been located on the surface. From the tunnel we proceeded to Sulphur creek, and down Sulphur to Granville, where we spent the night. On the 25th we returned to Sulphur, and down Hunker to Dawson. Next day, Bonanza, Eldorado, and Quartz creeks were visited. The night was spent at Quartz, and the following day we proceeded up Quartz to the Dome and down Bonanza to Dawson. The following day I accompanied Mr. A. N. C.

Treadgold to Hunker and Last Chance creeks, and spent the day on the White Channel gravels. On August 29, Mr. Templeman left Dawson for Victoria via Skagway, while I continued down the Yukon, to visit the placer camps of the lower Yukon and Seward peninsula, returning to Victoria via Nome.

### PRESENT CONDITIONS.

Gold mining in the Klondike is rapidly changing in character. Individual mining is being superseded by large scale operations, with such engineering and mechanical aids as water led in from a distance, electrical power, mechanical lifts, dredges, etc. The Yukon Gold Company is working on the largest scale, and is about to increase its effective operations. The Yukon ditch has been completed from Twelvemile to Gold hill, a distance of about 70 miles. In its course across country it is alternately ditch, flume, and pipe (the latter as a huge inverted syphon in crossing valleys such as the Klondike). Hillside springs and marshes present difficulties in maintaining the ditch, but it is rapidly becoming 'seasoned' by skillfully applied natural means, and, it is hoped, will soon have the stability of a natural watercourse.

Seven dredges are being operated successfully by this Company and three mechanical lifts. These plants are operated by electricity furnished by the Company's power plant near Little Twelvemile. The main, high-voltage transmission line is 36 miles long, besides which there are 18 miles of branch lines and 8 of secondary lines. In all, ten dredges are working in the Klondike, three on the river itself, five on Bonanza creek and two on Hunker creek.

A very extensive scheme for power development is under way on the Klondike river about 30 miles above Dawson. Water from the North Fork of the Klondike will be utilized to generate power to be transmitted over all the mining district. Individual claims are being rapidly consolidated, usually by purchase, into larger holdings. With a greatly increased number of plants, it will still take years to clean up the gravels of the district. Practically all the worked-over ground and underlying bed-rock will be re-treated by mechanical devices. High-level gravels for which there was no available water, and claims which by reason of mechanical difficulties could not be attacked by the individual miner, will furnish a big additional field for large-scale operation. McConnell, in 1906,[1] estimated future production at about $63,000,000, making no allowance for rich discoveries. The work done since then is said to have shown that this estimate was thoroughly conservative, and that the actual production will be considerably in excess of these figures.

Some attention is being directed to the quartz possibilities of the Klondike, and many claims have been staked. The neighbourhood of the Dome, Goldbottom creek, and Victoria gulch are the localities so far in most favour, but interest is not confined to these. Little work, however, has been done, and no decisive data have yet been obtained.

On the Dome property a tunnel is being driven into the hill from the Dominion Creek slope, with the intention of prospecting several quartz veins which it is expected will be cross-cut between 950 and 2,000 feet. The prospect is equipped with a small

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1 Gold Values in the Klondike High Level Gravels. Geol. Survey Publication, No. 979.

compressor plant, and at the time of our visit the tunnel was in 920 feet. For the first 150 feet the ground is frozen; inside the frost line, the rock is solid Klondike schist. A few slips occur and small quartz veins, also bunches of quartz and calcite. Most of the slips and veins dip into the hill, but a few with it. The movement along the slips appears to have been small. In one instance a slip faulted a 2 inch quartz vein, causing a displacement of about a foot and a half. These small veins give the impression of being persistent. The slips are not very numerous, and the ground inside the frost line is as solid and free from disturbances as in most mineralized areas. Near the surface, in the frost zone, the ground is broken into small blocks which are gradually working downhill. This 'creep' is quite pronounced. Since our visit, it is reported that two ledges have been encountered from which good assays have been obtained.

Near the close of the season, a two-stamp mill on the Lone Star group at the head of Victoria gulch made a test run of over one hundred hours on surface quartz, with results that are said to be entirely satisfactory. McConnell, in his report on the Klondike Gold Fields (p. 65), speaking of these veins says, 'the prospects are certainly encouraging, and warrant further investigation.'

The prospecting on the rock bluff 10 miles below Dawson, and below the Indian village of Moose-hide, shows that attention is not wholly confined to the placer creeks. The bluff consists of coarse, quartz-mica schists, with numerous quartz stringers, a few of which are said to pan gold. But the rock which attracted attention is a basic igneous dike which cuts the schists. On the exposed surface it is rusty-weathering with a marked spheroidal structure. We did not succeed in obtaining colours, but subsequent pannings are reported to have yielded positive results.

As yet there is nothing definite on which to base a judgment regarding the quartz possibilities, but there are facts in connexion with the geology of the district and the occurrence of placer gold, which have a bearing on the question, and furnish at least suggestions with regard to prospecting for quartz. Detailed descriptions of the district may be found in McConnell's Klondike Gold Fields (Geological Survey, No. 884), and his 'Gold Values in the Klondike High Level Gravels' (Geological Survey, No. 979), and need not be repeated here. But the salient points which strike the visitor may be worth mentioning.

## GEOLOGICAL HISTORY OF THE KLONDIKE.

The complete geological history of the district is, of course, somewhat more complicated than represented in the following notes. The district is not glaciated, and the present topography is the result of weathering and erosion. Viewed from an eminence, the streams are seen to possess wide valleys with gently sloping sides rising to rounded hills with broad, rather flat tops. Outcropping rocks are conspicuously absent. Broad amphitheatres at the heads of the creeks are characteristic. Rock-waste subdues the outlines of the hills, and deep gravel deposits cover the gently sloping valley bottoms. Here is seen a region in a state of advanced maturity. But rejuvenescence occasioned by a recent uplift is also observable. The Yukon has sawn a trench 700 feet or so into the bottom of the old valley. The Klondike, responding to this lowered base-level, has correspondingly trenched its old bed, and Bonanza and Hunker creeks have chan-

nelled their valleys in harmony with the new Klondike level. The creeks south of the Dome are still in the old channels, for the Indian river has not yet advanced its new cañon as far up as the mouths of these streams.

For a period extending a long distance into the geological past, conditions of weathering, erosion, and deposition have obtained, with no disturbances sufficient to seriously interrupt these processes, to erase their effects or sweep away their products. This fact, brought into notice by the topography of the district, is accentuated by an examination of the gravels themselves. The old valleys, except where covered by recent accumulations or cut into by the rejuvenated streams, are floored with 'White Channel gravels,' which rest on a yellowish, clay-like bed-rock, the weathered, rotted country rock. The 'White Channel gravels' themselves are bleached mixtures, consisting largely of fine sericite and quartz pebbles. Pebbles of country rock have decomposed and fallen to pieces, or if present, disintegrate at a touch. Stratification is gone. Decomposable minerals have broken down. Soluble elements have been leached out, and stable combinations like sericite formed of what remains. Magnetite is practically absent, though originally it must have been plentiful. Only the most resistant minerals, such as quartz and sericite, with some gold, are left. Weathering, therefore, has been an important and long-continued process on the rock surfaces, in the hillside wash, and, finally, in the stream accumulations in the valley bottoms.

The country rock consists of sericite and chloritic schists, with some dark, graphitic argillites cut by some dikes of igneous rocks, quartz porphyries, rhyolites, and andesites. Quartz veins and stringers, some, at least, gold-bearing, are abundant in these schists. Exposures are not numerous, being largely confined to occasional outcrops on the summits or in the cañons of the rejuvenated streams. But the large amount of quartz in the debris which mantles the solid rock evidences the presence of quartz veins where they are not exposed.

The old White Channel gravels, representing a natural concentrate from a great mass of gold-bearing material through long ages, by weathering and stream action, are rich in gold. The gold occurs in a well defined paystreak, as is usually the case in stream gravels. The present stream beds where they have cut down through the White Channel paystreak were enormously rich, as might be expected since they represent a reconcentration of an already rich concentrate. Where the White Channel paystreak was untouched, the present stream bed was apt to prove lean. Going up stream, the gold usually becomes less worn, rougher, more angular, and coarser. The gravels are not always of pay grade to the heads of the creeks nor always to the mouths of the creeks; some of the tributary gulches are rich and some have proved barren. Often gulches which head together are paired as to gold contents. If one is rich the other is rich; if one is poor the other is poor. Gold in the recent gravel freshly derived from its original source is similar to gold in the corresponding White Channel gravel. Many of the gold grains and most of the nuggets, enclose quartz. Quartz pebbles are found containing gold, some at least very rich in gold. The quartz of the boulders is similar to the quartz of the veins, and gold of the veins to the gold of the gravels. From the foregoing and other facts, it is obvious that the gold is absolutely local in origin, derived from the basins of the pay gulches and creeks.

## QUARTZ POSSIBILITIES.

The extraordinarily rich gravel represents the concentration of a great mass of gold-bearing material. There are several possibilities regarding the source of the gold. It might be derived from disseminations through the country rock. A gold value of a few cents a ton, such is the volume of country rock weathered and eroded, would more than account for all the millions in the gravels. But this interpretation does not fit the facts. In addition to those above alluded to, it may be recalled that Eureka creek, which is gold-bearing, is not in the Klondike schists at all, but in the Nasina series, which almost everywhere else is unproductive. It is then practically certain that the gold of the gravels has come from the quartz veins. When one considers the extremely local occurrence of the gold, the suggestive form of the nuggets, the overwhelming importance of quartz in the gravel, the widespread occurrence of quartz in the very nuggets themselves, the 'kindly' appearance of the quartz of the pebbles and the actual occurrence of gold in this quartz and also in some of the veins so far uncovered, the numerous veins on the rich creeks, etc., no other view seems at all tenable. But granting this, there still remain several possibilities. The gold may be somewhat uniformly distributed throughout the innumerable quartz stringers and veins, in which case they would almost certainly be too lean for profitable exploitation. The probabilities, however, are that this is not the case, and such facts as are known do not suggest this possibility. To begin with, this is not the usual characteristic of gold-quartz veins. Again, quartz is widespread; gold confined to particular creeks and gulches. Some of the quartz boulders are likely-looking, some very unpromising; suggesting that they are from veins of different origin and contents. Other facts also tend to indicate that the gold is confined to certain veins. The large nuggets and the richness of the gravels at the heads of some of the pay channels would suggest that in the auriferous veins themselves the gold is already concentrated to a certain extent at least. The rich kidney of quartz found on the New Bonanza claim, Victoria gulch, is an example.

Up to this point, the argument is all in favour of the possibilities of rich quartz veins, but here some uncertainties enter. The gold might be concentrated in ore shoots, as is usually the case in veins. These might be large and workable bonanzas or small and pockety. The pay ore may have been largely removed by erosion, and for the most part, only low-grade roots of veins left. Veins, though rich, might be too small or irregular for mining. McConnell admits that most of the veins seen by him were of this character. On the other hand, comparatively few of the veins have been exposed, and it is quite possible that large and regular veins are to be found. So far, developments on the Dome property tend to strengthen this possibility. Moreover, the small veins might occur in groups or zones that collectively might be capable of development, or the country rock in the neighbourhood of a vein might prove sufficiently mineralized to give workable dimensions to the ore body. There is not yet sufficient information available to determine the actual conditions in the Klondike with respect to these last points, so that the future of the lode mining cannot be predicted with certainty. As just shown, the balance of the evidence, so far as it goes, is distinctly favourable, and the stakes are tempting. In my opinion, then, it is well worth while making serious attempts to locate workable quartz.

In this connexion it is interesting to note that prospecting for quartz in the placer camps of Alaska is furnishing encouraging results. Some promising gold-quartz has been found in the Koyukuk and Chandalar regions. At Fairbanks, according to information furnished by A. H. Brooks, of the United States Geological Survey, prospecting for quartz or veins has been carried on at a number of points. Veins varying from less than an inch wide to 12 feet have been found. The rich ore has thus far been confined to stringers or veins under 3 feet thick, but valuable material is reported in places in the adjoining country rock. Though many of the individual stringers pinch out and some of the veins are faulted, others may be followed for several hundred feet. Development work is as yet limited, but the prospects are considered sufficiently encouraging to warrant serious development and further prospecting for quartz veins.

On the Seward peninsula, quartz seems to be receiving greater attention than ever before. This autumn a magazine was started at Nome in the interests of quartz mining on the peninsula. The Big Hurrah mine, in the Solomon River region, has been operated for a number of years, and has the distinction of being the first lode mine on the peninsula. It has a stamp mill, and seems to have demonstrated that in certain spots at least, mineralization is sufficiently concentrated, and veins sufficiently large and continuous, to make a lode mine. Here is one place where a northern placer has developed into a lode mine, and where some of the placer gold has been traced to its source.

## NOTES FOR PROSPECTORS.

The prospects for developing lode mines in the Klondike I would consider to be quite as promising as in the lower Yukon. The most attractive prospecting ground is naturally on the creeks which have had rich gravels, for since the gold is local in origin and, presumably, derived from quartz, they indicate the existence of auriferous veins in their basins. Some guidance as to the best points to prospect in the individual basin is furnished by the gold in the gravel. For example, the head of a creek or a tributary gulch that has a bed-rock which would retain gold, but does not contain pay gravel, would be an unpromising field for prospecting. On the other hand, the valley walls or the gulches at the head of pay gravel would be likely ground. For instance, Victoria gulch with No. 7 pup is almost at the head of the productive part of Bonanza creek. The gold is coarse, and in the upper part very rough and angular. Here, evidently, one is 'hot on the scent.' On No. 7 pup the gravel is angular, and consists of almost unworn slide rock. This should be a good place to prospect. Gay gulch, which heads with Victoria gulch, is also auriferous. This and the divide between the two gulches furnish favourable ground. A study of the geological maps and reports, and a consideration of the production from the various claims, will furnish numerous suggestions regarding other good points for attack.

When the gravels of a creek appear to be enriched on a certain claim as if from a local source of gold, it should first be determined if the excess supply has been derived from the White Channel paystreak. Only when this has not been the case may such enrichment be taken to indicate the presence of a rich vein in the immediate vicinity.

If coarse or unworn gold suddenly makes its appearance where normally only fine and worn gold might be expected, this would be indicative of a fresh, local supply from a nearby source. Such would be a favourable place to prospect.

Prospecting will be slow and tedious, hampered as it is by the lack of rock exposures and the mantle of loose rock. The latter is steadily creeping down hill, a point to be remembered when float is discovered. When a vein is found and sufficiently uncovered to show the character of the vein material unmixed with 'wash,' unless it is of pay grade it is usually unwise to sink on it or otherwise test it at depth in the hope that values will improve. If it is felt to be worth further development, it is usually better to prospect it horizontally rather than vertically. This can be done either by trenching, or if the cover is too deep, by drifting. Either will be cheaper and more rapid than sinking, and will test the vein as successfully, for the chance of striking better grade material along the vein is quite as strong as, if not stronger than down it, and much more of the vein is tested in the same time and for the same money. If, however, pay ore is encountered, it is advisable to sink on the ore as well as to follow the vein horizontally, for gold often exhibits a tendency to concentrate on the surface, and it is, therefore, necessary to demonstrate that the values continue downward. Until the ore shoot is well developed, so that certain knowledge is to be had of its position, dip, continuity, value, etc., in no case should expensive work be undertaken elsewhere than on the ore, under the assumption that it goes down, or has any particular attitude. 'Stick to the ore' is advice to be heeded. These points may seem too elementary to be worth making, but justification is furnished by the amount of money wasted in young camps, everywhere, by disregarding them, and by the frequent expenditure of time and money in a way that detracts from rather than adds to the value of the claim.

For the encouragement of prospectors it may be noted that, up to a certain point, the greater the number of veins that prove barren or almost so, the greater are the chances that some occur that are rich, for the reason that the fewer sources there are for the gold, the richer these sources must be.

Some light on the value of the quartz of veins might possibly be had from the quartz boulders of the gravels. Many will no doubt be from barren veins; many are cavernous. These probably held auriferous sulphide minerals which have been leached and the accompanying gold dropped out, in which case the values found would be too low. But tests made with discrimination and judgment might furnish some instructive results.

## PLACER PROSPECTS.

It is to many a matter of surprise that the discovery of the Klondike has not been followed by that of other important placers in the Yukon. The possibility of this is not yet exhausted. Prospectors from the Stewart are bringing out encouraging reports of creeks, tributary to this river. In some respects the conditions are very favourable for placer mining. From information which appears to be reliable, the placer prospects of the Stewart River district are to be taken seriously. Two dredges are being operated on the river.

Information obtained from the Klondike may be used with advantage in prospecting for new placers. Here, as noted above, the essential points were, gold-bearing country rock (auriferous by reason of gold-bearing veins), a very long period of concentration of the gold through weathering and erosion with, in places, a reconcentration of the already rich gravels. The same conditions were essential in the formation of the placer camps of the lower Yukon—notably at Fairbanks and the Seward peninsula. (At Nome reconcentration was effected on several beach lines.)

The presence or absence of the essential factors in a district, except the auriferous character of the country rock, can be speedily recognized by an inspection of its topographical features and the condition of the surface and of the old gravels. Whether the country rock is gold-bearing, and so could have supplied gold to the gravels, is not so readily determined, but in certain cases, at least, this can be more readily ascertained (or at all events its probability indicated) by an examination of the materials of the gravels, the slide rock, and outcrops than by the more laborious digging and washing of the gravels.

For instance, in the Klondike, the amount of quartz, and particularly the suggestive character of the quartz in the numerous milky, cavernous boulders, would indicate a strong probability of the occurrence of gold, which, coupled with the pronounced evidences of mature weathering and erosion, and reconcentration, would have attracted the observant prospector and encouraged him to expend the necessary time and labour to thoroughly test the gravels.

If these underlying principles regarding the formation of placers are borne in mind, it will assist one in eliminating unpromising districts and in confining his attention to creeks where there are inherent possibilities for success.

## Other Districts.

Placer mining is still in progress on tributaries of Sixtymile and on Fortymile rivers. Dredging is in progress on the latter.

The Sourdough coal mine below Fortymile river is in operation.

## White River District.

The encouraging developments of the copper properties on Copper river, Alaska, to which a railway from the port of Cordova is being built, and the similar prospects on the north side of the Wrangell mountains in the Nabesna-White River district, has re-awakened interest in the possibilities of the upper portion of the White river on the Yukon side of the International Boundary line.

In 1905, McConnell made a reconnaissance survey of this district, his report being published in the Summary Report of the Geological Survey for 1905 (pages 19-26). In 1907, very fine specimens of rich bornite and chalcocite were brought out from this district.

In 1908, Messrs. Moffit and Knopf of the United States Geological Survey, examined the Nabesna-White River district, Alaska. Portions of their report[1] of special interest to Canadians, because referring to the Yukon, are here reproduced:—

[1] Mineral Resources of Alaska, 1908, United States Geological Survey Bulletin 379, pp. 161-180.

'COPPER.

## General Conditions of Occurrence.

'The reported presence of native copper in vast quantities was, as already pointed out, the original incentive that drew the pioneer to the White-Nabesna region. Prospecting in search of these deposits has shown that copper in its bed-rock sources is widely distributed in the form of sulphides (chalcocite, bornite, and chalcopyrite), and on the basis of the facts revealed by the little development work that has been done, it may be stated that most of the native copper found in the region is an oxidation product of those sulphides. In mode of occurrence the copper ore shows two different habits, geologically distinct. In one, so far the better known, it occurs associated with the Carboniferous basaltic amygdaloids, and in the other it is found in limestone at or near the contact with the dioritic intrusives.

'Native copper occurs as nuggets in the gravels of many of the streams, and green-coated lumps of metal up to 5 pounds or more in weight are occasionally found in the wash of creeks draining areas of amygdaloid bed-rock. This stream copper was the source from which the Indians obtained their supply when it was an object of barter among them. From the accounts of Hayes and Brooks, Kletsan creek appears to have been the placer locality best known to the natives.

'Metallic copper occurs also in the surface croppings of sulphide deposits in the amygdaloids, where it is undoubtedly an oxidation product of the sulphides that appear in depth. In such places it is directly associated with the dark-red oxide (cuprite) and more or less green carbonate. At the prospect known as 'Discovery,' which is located in Canadian territory on White river, a few miles below the International Boundary, a large slab of native copper averaging 8 by 4 feet by 4 inches thick, and weighing probably close to 6,000 pounds, has been uncovered in the slide rock. A number of other sheets of copper up to several hundred pounds in weight have been found in the near vicinity. On account of the stimulus that this find has exerted on the prospecting of the adjacent American territory, the occurrence merits some description in this report. The stripping of the bed-rock near the great nugget exposes a face of green basaltic amygdaloid 20 feet high and 15 feet wide. The rock is traversed by numerous seams of native copper along fractures and slickensides, but toward the bottom of the open-cut stringers of chalcocite begin to appear. About 150 feet from this prospect an opening on an independent occurrence shows stringers of cuprite with admixed copper, stringers of glance and calcite, and chalcopyrite disseminated through the amygdaloid country rock. From these features it is clear that the metallic copper of this deposit is a superficial oxidation product of sulphides, that its downward extension is small, and that the prevailing sulphide at greater depth will probably turn out to be chalcopyrite.

'At a few localities native copper is associated with certain highly amygdaloidal portions of the Carboniferous basalts and intergrown with the white minerals that fill the former steam cavities in the ancient lava flows. Slaggy looking portions produced by the weathering and removal of the amygdules from the lava and amygdaloid that is cut by small irregular veinlets filled with the same minerals as those forming the amygdules appear to be the most favourable places for metallic copper. The copper in

the vesicles and stringers is associated with calcite and delicately spherulitic prehnite, but in some of the veinlets calcite, prehnite, quartz, a black lacquer-like mineral, partly combustible, and chalcocite, instead of metallic copper, are associated together.

'At a number of places throughout the region narrow stringers of chalcocite cutting the ancient basalts are encountered, but so far as known none have any great persistence. Near the head of Cross creek, locally known as Copper creek, a thin quartz-chalcopyrite vein cutting the bedded volcanic rocks has been discovered. At other localities some irregularly disseminated sulphides, in some places chalcocite, in others bornite, occur in the basalts, but these do not appear to be connected with definite vein or lode systems, and are consequently of an unencouraging character. Oxidation of these sulphides and disintegration of the containing rock give rise to the nuggets of cuprite and native copper that are found in the talus slopes at several places in the region.

'In contrast to these occurrences, which, as shown by the foregoing discussion, are limited to the ancient basalt flows, copper is found as bornite and as chalcopyrite intergrown with contact-metamorphic rock in limestone adjoining diorite intrusives. In deposits of this type the ore mineral is associated with garnet, coarsely crystalline calcite, epidote, specular hematite, and scattered flakes of molybdenite. The garnet is commonly crystallized in dodecahedra, and is intimately intergrown with the bornite and chalcopyrite. On account of its weight and especially its appearance, which is not unlike that of cassiterite, it was mistaken for tin ore by some of the early prospectors. Only two deposits of this character were seen in place, but evidences of energetic contact metamorphism were detected at a number of other localities. An extensive contact zone has been produced along the junction of the diorite and the massive limestone exposed on the ridge west of Copper pass. Various contact-metamorphic rocks, pyritiferous as a rule, are present in this zone, and these rocks on oxidizing give rise to large iron-stained outcrops, which contrast strongly with the surrounding white limestone. In connexion with the discussion of the contact-metamorphic deposits, it may be stated that the writers were shown some specimens of copper ore containing abundant large octahedra of magnetite and blebs of chalcopyrite in a gangue of coarse calc spar. This ore was undoubtedly obtained from the vicinity of an intrusive diorite-limestone contact, but whether commercially valuable ore bodies of this character exist in this region, which is so remote from transportation facilities, is yet to be demonstrated, in view of the fact that copper deposits of contact-metamorphic origin are characteristically bunchy and low grade.'

## 'Conclusions.

'The White-Nabesna region can be more easily prospected in some respects than many other parts of Alaska, on account of the relative abundance of bed-rock exposures. Most of the showings of ore found thus far are situated well up on the mountain sides, generally beneath walls of rock cliffs and above the encumbering talus slopes. This is, of course, to be expected in a region that is incompletely prospected, but it entails the disadvantage that the prospects are located far from timber. The greater number of the copper prospects are found in the Carboniferous basaltic amygdaloids, a relation which is also essentially true for those of the Chitina country.

The geologic investigation of the region has established the fact that these volcanic rocks have a considerable distribution, and underlie the greater part of the Wrangell mountains. Much of this territory, however, is unfortunately not accessible on account of its numerous glaciers and extensive ice fields.

'The main interest of the White-Nabesna region has centred in the occurrences of native copper. No phenomenal ore bodies have yet been discovered, but it has been shown that primary native copper occurs in the amygdules of zeolitic amygdaloids, a mode of occurrence unknown on the Chitina side of the Wrangell mountains. This discovery is sufficiently encouraging to warrant further development, and it is hoped that the nature and extent of the deposit will soon be demonstrated.

'From the descriptions given in the preceding pages, it will be apparent that a lode-quartz region of some promise has been discovered in the Nutzotin mountains, near the International Boundary, and that, as yet, it has been but imperfectly explored by the prospector. It was shown that the intrusion of quartz diorite produced a number of contact-metamorphic bodies of copper sulphides, and the occurrence on Jacksina creek suggests that the magma was also capable of effecting an auriferous mineralization. From the meagre data at hand it is perhaps unsafe to venture on generalizations, yet it is probable that the quartz veins are genetically related to the intrusion of the post-Carboniferous quartz diorites and that, therefore, the intruded areas are those most likely to be mineral bearing. Such areas are known to occur throughout the Nutzotin mountains at a number of localities, especially along the northeastern flanks. Brooks has mapped a large area of granular intrusive on the lower Nabesna. It is probable that in the vicinity of such masses the search for lode quartz may be prosecuted with the most hope of success.'

## WEST AND EAST KOOTENAY.

From Victoria I went to Nelson, and attended a meeting of the Western Branch of the Canadian Mining Institute. Messrs. LeRoy and Boyd, who were engaged in Geological Survey work in the Slocan, were in Nelson to report progress.

### Earl Grey at Ainsworth Cave.

His Excellency Earl Grey and party, who had ridden over the pass from their camp on Toby creek, were met at Argenta, at the head of Kootenay lake. His Excellency proceeded to Ainsworth, to visit the cave above the town, which had been only partially explored last season.[1] The party to explore the cave included Earl Grey, Lady Sybil Grey, Lady Evelyn Grey, and the Hon. Miss Brodcrick. After going to the head of the cave, a feat demanding some daring as well as skill, the lower unexplored portion was assailed. This proved disappointing, since, instead of opening up into a larger cavern as anticipated, in 100 feet the chamber closed up, the water escaping down a fissure too narrow to be followed. Evidently until a comparatively recent date the large chamber at the entrance formed the lower limit of the cave, and the water has for a short time only been at work on the fissure through which it now drains.

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[1] Summary Report Geological Survey, 1908, pp. 21-22.

## Kootenay-Columbia Divide.

Through the kindness of His Excellency, who proffered his saddle horses and camps, the writer, accompanied by Mr. Boyd, was able to cross over to the Windermere district by way of Hamill and Toby creeks.

From Argenta to Hamill creek, a distance of three miles, an old railway grade (constructed by the Great Northern railway from Argenta to Howser lake) is used as a wagon road. Crossing Hamill creek the road enters a cañon. For about a mile and a half the creek rushes through a deep box-cañon, one of the most beautiful and impressive of its kind in British Columbia. Bands of white and bluish marble form a considerable part of the almost vertical rock walls. The road is carried up on a rock cut shelf supplemented by trestles, but owing to small slides it is not now passable for wagons. Three miles up, at the head of the wagon road, is the Argenta compressor. The mine is situated on the hillside a couple of thousand feet above, but is now idle. A short distance above the compressor the trail skirts a burnt hillside, but soon enters a verdant forest, and from here to the head of the creek the natural beauty of the forest is unimpaired. The first camp was on Hamill creek in a meadow at the base of the climb to the pass. Up to this point the grade had been easy. A somewhat steep climb of a couple of thousand feet brings one to the level of the pass, which is low and easy considering the rugged nature of the mountains through which it leads. Several alpine glaciers lie close to the trail. Some of the peaks exceed 10,000 feet in elevation, and from their summits is to be seen one of the finest and most extensive panoramas in the Canadian Cordillera. Unfortunately when we were on the pass it was enveloped in fog, but in our Lardeau work we had occupied, as stations, peaks a few miles to the east, from which we gained a view of the country.

The trail from the summit down Toby creek has an easy grade. For the first half mile it is above a glacier. About eight miles down, on an open hillside, commanding a fine view of the valley, is the headquarters camp of His Excellency.

The character of the country on the Columbia slope is distinct from that on the Kootenay side of the divide. The vegetation is less dense, showing evidences of a drier climate, and altogether there is a sort of transition between the pronounced Selkirk type, and the Rocky Mountain type of country.

About 12 miles below the camp the trail joins the B.C. wagon road at a point about 18 miles from Wilmer, on the Columbia.

## Suggested Parks.

These two valleys of Hamill and Toby creeks, with the adjacent mountains, particularly the portion from Argenta to Earl Grey's headquarters camp, form one of the most attractive of the easily accessible mountain districts in British Columbia, and the suggestion that they be reserved as a provincial park is well worth carrying out.

With rail communication to supplement the present boat service, as there soon will be along the Columbia-Kootenay valley from the Canadian Pacific Railway main line at Golden to the Crows Nest Pass line, and with the boat service on Kootenay lake, such a park would act as a strong magnet to tourists.

Another magnificent site for a park exists up the Duncan river, in the 'Lime dike' country, about the head of Hall, Haley, Caribou, Gainer, and Porcupine creeks. Here the scenery is of the peculiarly wild, airy type of the famous 'Dolomites' of the Tyrolean Alps. It is also of easy access for an energetic tourist.

Such parks would mean a great deal in the future tourist travel in southern Kootenay, which can soon be made one of the big 'industries' of the Province, so that in addition to preserving in its natural state the grandest of mountain scenery, and forming a game and timber reserve, they would become most valuable provincial assets.

## Geology.

The trip was made too hurriedly for geological work, which, on account of the folding and other disturbances, would have to be done in detail.

The rocks up Hamill creek consist of schists, often garnetiferous, slate, limestones, and quartzites. Near the summit is a fine-grained conglomerate.

On Toby creek, slates and limestones extend to Earl Grey's camp. From here to the wagon road are quartzites and dolomite. The rock at the wagon road is a heavy green schist. Up the little cañon of a tributary stream which the wagon road to the B.C. mine follows, is a succession of 'soda springs,' giving off carbonated waters containing lime and iron, and which have deposited a red tufa.

For several miles below Pinehurst, where the road to Paradise mine takes off, is a conglomerate, in some places coarse and in others fine, with boulders and pebbles of limestone, slate, and jasper. The dip here is about 45° west.

About 8 miles from Wilmer the rocks appear to be mainly flat lying. Along the lower end of the road, limestone and schists occur, rather massive and crystalline, having an older appearance than the rocks previously encountered. Some jasper-like bands which may have yielded the pebbles seen in the conglomerate were also noticed.

Very little activity in mining or prospecting was reported in the Windermere district. With the building of the railway there will probably be a renewal of interest in this section, for many promising leads with ore of good value have been found and partially developed, and from some considerable shipments have been made, in spite of the present difficulties of transportation.

The Paradise, on Spring creek, a tributary of Toby, is the best developed mine. It has over a mile of workings, and has shipped more than 2,000 tons of ore taken out in development, which is said to have yielded average smelter returns of 57·44 ounces of silver and 58·9 per cent of lead to the ton.

W. Fleet Robertson, who visited the property in 1903,[1] states that, 'in the mine workings much ore is in sight and more is demonstrated almost to a certainty. A rough calculation made at the time (July, 1903) gave, if not of ore actually 'blocked out' certainly of 'probable ore,' about 50,000 tons, which amount there is every reason to expect has been largely increased by subsequent developments.'

Most of the veins in the district are silver-lead, though some have gold-copper or zinc values. The silver is usually carried in tetrahedrite, and the gold in pyrite. Some

[1] Report of the Minister of Mines, B.C., 1903, p. 101.

veins from which shipments have been made have produced rich ore, carrying several hundred ounces to the ton.

### Trail Creek Mining Division.

From Wilmer, we took the steamer down the Columbia to Golden, and returned to Nelson. Half a day was spent at the smelter and refinery of the Consolidated Mining and Smelting Company at Trail, and a day at Nelson.

The smelter at Trail is probably the largest and most complete of its kind in America. It is designed to treat all the varied ores produced in the Kootenays with the exception of zinc. The mines owned by the Company assure a steady, heavy tonnage of the various classes of ore required, but all the custom ore offered is also purchased, thus affording the smaller mines the advantage of large scale smelting operations. During the year a new lead furnace, with a capacity of 250 tons, replaced one of the two, old 140 ton furnaces. Mechanical feeds were provided for both the lead furnaces. A new copper furnace of 450 tons daily capacity replaced a smaller furnace, and a No. II Root blower was added to the plant. An additional Huntington Haberlein roaster was installed, and another is being erected. The capacity of the lead refinery has been doubled during the year.

The daily capacity of the plant is now 2,100 tons of gold-copper ore, and 500 tons of silver-lead ore, and that of the refinery is 120 tons of pure lead. The chief products of the plant are refined gold, silver, and lead; sulphate of copper; electrolytic bearing-metal; and gold-copper matte. The output for the year will probably exceed $5,850,000 in value, notwithstanding the low price of metals. The copper matte is sold to the Tacoma refinery; the gold to the United States Assay Office; the silver to the Canadian market including the Canadian Mint, also to China; the lead supplies the Canadian market, the surplus being disposed of in China and Japan.

The development of the Centre Star mines at Rossland has been vigorously prosecuted, over 3 miles being added during the year to the 20 miles of workings. A number of extensive new ore bodies were opened up through this development work, especially on the War Eagle. The Le Roi No. 2 has maintained its record as a steady producer and dividend payer.

The output of the Rossland camp for the year, however, will be lower than usual, owing to the fact that the Le Roi, until recently much the heaviest shipper, has produced very little ore this year. A vigorous policy of exploration has been carried on in the Le Roi during the latter half of the year, which it is hoped will result in important developments.

The Evening Star and Blue Bird were operated for a time, and the Velvet was about to be reopened at the time of my visit.

### Turtle Mountain.

On the return journey to Ottawa, a stop of a day was made at Frank, Alta., to examine Turtle mountain, especially the north shoulder above the town. The summit now presents a more dilapidated appearance than immediately after the great landslide. The breaking away of material back to the limits of the cracks formed at the time of the slide, leaves a more widely gaping hole, with the north shoulder outstand-

ing. A large amount of material has still to come from the south peak, which is traversed by two major crevasses some distance back from the face of the cliff. This peak is so situated that falls from it are not likely to cause damage. On the north peak, overlooking the town, a break is not impossible, especially if artificial excavations are made near its base. A rather fresh looking crack extends across the ridge and down the west slope between the summit of the north peak and the shoulder overlooking the town. Two cracks parallel to the face of the ridge occur on this shoulder between the main ridge and the edge of the cliff.

While, on this shoulder there is little or no evidence of movement, and it still presents an appearance of solidity, it must not be forgotten that it is projecting outwards without support except at the west end, and that its cliff face is high and steep. The same causes which brought about the former catastrophe might produce a similar effect upon this shoulder of the mountain. If a large mass were detached from it, it would certainly reach the valley bottom, and there is nothing, as there was in the former slide, to prevent its spreading fan-like down the slope and over the valley bottom.

## BORING ON PRINCE EDWARD ISLAND.

The surface of Prince Edward Island is composed of rocks belonging to the group now spoken of as Permo-Carboniferous. Ever since the first geological examination made on the island, the possibility has been recognized of the underlying Carboniferous containing an extension of the coal basins of Cape Breton and Nova Scotia.

Unfortunately, surface study cannot throw any light on this question. The strata are nearly flat, and only a limited section of the rocks is exposed.

Information can be obtained only by boring. The Provincial government recently appealed to the Dominion to undertake this investigation, pointing out that, although under the terms of confederation geological investigations should be carried on in Prince Edward Island, little had been or could be done, and suggesting that, in lieu of surface studies, geological sections by means of bore-holes be obtained.

If coal were found within commercial distance of the surface it would mean much to the island. There was also a possibility that gas or oil might be encountered. Moreover, any information gained would be valuable to the neighbouring provinces. The proposal of the Prince Edward Island government was, therefore, accepted, and a sum allotted for the work.

For a complete and satisfactory test, four or five deep holes at selected points on the island would have to be drilled. To get this done for the money available, in rocks which, from a drilling standpoint, were unknown, the cheapest and best all round mode of drilling would have to be employed. A contract was accordingly let to an experienced driller for 10,000 feet of boring with a standard drilling rig (churn drill).

Several low anticlines cross the island, and as the strata exposed on these belong to a lower horizon than is to be met with elsewhere on the island, and as anticlines form the most likely points for gas or oil reservoirs, the sites for bore-holes were selected on these. From the work of Sir William Dawson and Dr. Ells, the anticline at Gallas point appeared to be the best spot for the initial hole, as the rocks there were supposed to be the lowest strata exposed on the island.

No. 1 hole was located on the farm of Jas. Tweedie. This is a little south of the axis of the anticline; but because of the low dip it was unnecessary to locate precisely on the axis to secure depth; moreover, the chances for gas or oil are better a little off the axis. It was started as a 10 inch hole.

Hole No. 2 was located about two miles north, on the other side of the axis, where the surface rocks appeared more solid, in the hope that water-bearing strata, encountered in No. 1 hole, might be less pervious on the north limb of the anticline. In order to increase the chances of attaining depth, the diameter of this hole was increased to 13 inches.

Hole No. 3 was bored near Kinross on the same anticline, but about 7 miles inland. This and the remaining holes were started as 18 inch holes.

Hole No. 4 was drilled near Little Sands, on the next recognized axis. This was the nearest spot on the island to the known coal fields of Nova Scotia (Pictou basin). This anticline and the preceding one, in their southwesterly extensions, pass on either side of the Springhill coal basin, in Nova Scotia.

Hole No. 5 was located near Miminegash, on the west side of the island, as close as possible to the axis of the most westerly anticline.

The drilling was done by contract, the Survey having a representative at the well to examine the drillings, keep the log of the well, and to forward samples, taken every 10 feet, to the department, where they were again examined and filed.

## Well Boring Logs.

Mr. E. D. Ingall, of the Boring Division, furnishes the following logs of the wells from an examination of the samples in the office and from the records kept by Mr. Ferguson, who looked after the interests of the Survey on the ground.

It will be noticed that more than ordinary efforts were made to push the borings to great depths. Ordinarily an 8 inch hole is deemed sufficiently large, whereas No. 1 was started as a 10 inch, No. 2 as a 13, and the remainder as 18 inch holes. The softness of certain strata and the number of heavy water-bearing beds encountered made it impossible to get much below 2,000 feet.

### PRINCE EDWARD ISLAND.

'*Bore-hole No. 1* (Boring Files No. 203). Prince Edward Island, Gallas point, near Charlottetown, Queens county.

'The rocks encountered were as follows, as shown by the samples of drillings:—

| | |
|---|---|
| Surface to 165 feet | Brownish, earthy shales. |
| 165– 215 feet | Brown, sandy, calcareous shales. |
| 215– 295 " | Brown, earthy shales mottled with greenish grey. |
| 295– 395 " | Blue-grey, sandy shale. |
| 395– 435 " | Grey, calcareous sandstones. |
| 435– 995 " | Brown shales. |
| 995–1,015 " | Purple-grey sandstone. |
| 1,015–1,125 " | Brown shales. |
| 1,125–1,155 " | Grey shales. |
| 1,155–1,165 " | Brown sandstone. |
| 1,165–1,190 " | Brown shales. |
| 1,190–1,205 " | Grey shales. |
| 1,205–1,395 " | Brown shales. |
| 1,395–1,405 " | Brown sandstone. |

| | |
|---|---|
| 1,405–1,620 " | Brown shales. |
| 1,620–1,650 " | Brown sandstone. |
| 1,650–1,660 " | Red-brown, sandy shale. |
| 1,660–1,880 " | Brown shales getting redder towards bottom. |
| 1,880–1,900 " | Coarse grey sandstone. |
| 1,900–1,910 " | Brownish-grey shaly sandstone. |

'Soft water was encountered at 35 to 45 feet and 150 feet, and salt water at 635 feet and 1,875.

'The hole was started with a 10 inch drive pipe and an 8 inch casing, which had to be reduced, owing to water and caving. At 1,800 feet a cave took place, necessitating the introduction of a string of 5⅝ inch casing. At 1,910 feet the soft, porous sandstone was caved through the pressure of the salt water.

'The samples from the series of beds passed through in this hole, effervesce freely with acid, showing the presence of carbonate of lime and, possibly, of magnesia, the only exceptions being the samples from some of the sandy beds.

'*Well No. 2* (Boring Files No. 205). Two and a half miles northeast of Earnscliffe, Queens county.

'The log of this well was as follows:—

| | |
|---|---|
| Surface to 750 feet | Reddish-brown, calcareous shales. |
| 750– 790 feet | Reddish-grey, calcareous sandstone. |
| 790–1,090 " | Reddish-brown, calcareous shales, somewhat mottled with greenish grey. |
| 1,090–1,140 " | Purplish-brown sandstone. |
| 1,140–1,230 " | Purplish-brown sandy shale. |
| 1,230–1,420 " | Brown shale. |
| 1,420–1,480 " | Purple-brown sandstone. |
| 1,480–1,495 " | Purple-brown shale. |
| 1,495–1,530 " | Purple-brown sandstone. |
| 1,530–1,550 " | Red-brown shale. |
| 1,550–1,570 " | Purple-brown sandstone. |
| 1,570–1,665 " | Purple-brown sandy shales. |
| 1,665–1,680 " | Purple-brown sandstone. |
| 1,680–1,685 " | Purple-brown shale. |

'At this depth it was found impossible to drill further, and the hole was abandoned. Water was encountered in the hole at 8 feet below the surface, and again at 55 feet, and at 750-1,100 and 1,450 feet salt water came in. The latter three depths, it will be noted, coincide with beds of sandstone penetrated.

'The hole was cased with 10 inch pipe to 600 feet; with 8½ inch pipe to 926 feet; with 6¾ inch pipe to 1,374 feet, finishing up with 5 inch pipe to 1,464 feet.

'*Log of well No. 3* (Boring Files No. 206). Prince Edward Island, Queens county, one-half mile northeasterly from Kinross, and one mile east of Glencoe station:—

| | |
|---|---|
| Surface to 10 feet | Argillaceous sand, red. |
| 10– 40 feet | Red, sandy shale. |
| 40– 50 " | Red, gravelly shale. |
| 50– 80 " | Red, sandy shale. |
| 80– 90 " | Red sandstone. |
| 90– 140 " | Red, sandy shale. |
| 140– 150 " | Red sandstone. |
| 150– 160 " | Red, sandy shale. |
| 160– 170 " | Red shale (Conglomerate), pebbles of limestone, sandstone, and shale, some stained greenish. |
| 170– 190 " | Red shale, mottled with green. |
| 190– 230 " | Red, sandy shale, mottled with green. |
| 230– 255 " | Reddish sandstone, rather coarse to finer grained. |

| | |
|---|---|
| 255– 260 feet | Red, soft shale (water still fresh). |
| 260– 330 " | Red, sandy shale, hard with occasional hard beds of purer sandstone, as shown by working of the drill. |
| 330– 350 " | Red shale, soft. |
| 350– 380 " | Red sandstone, coarse to fine and shaly. |
| 380– 400 " | Red, soft shale. |
| 400– 410 " | Grey sandstone. |
| 410– 430 " | Medium hard, red shale, with sandy, gravelly layers. |
| 430– 440 " | Micaceous and calcareous shale. |
| 440– 470 " | Fine to coarse grained, red sandstone, moderate supply fresh water. |
| 470– 530 " | Medium hard, red sandstone with some shaly layers. |
| 530– 560 " | Red, sandy shale. |
| 560– 590 " | Soft, red sandstone. |
| 590– 710 " | Sandy shale, red, with some purer shale layers. |
| 710– 830 " | Soft, red shales, with occasional layers of marl often mottled with green. |
| 830– 900 " | Shaly sandstone, red, with occasional shale and sandstone layers. |
| 900– 910 " | Calcareous, red sandstone. |
| 910– 930 " | Gravelly shale. |
| 930–1,030 " | Soft, red sandstone. |
| 1,030–1,080 " | Calcareous, soft red shale. |
| 1,080–1,340 " | Sandy shale, shaly sandstones, red and soft, fine grained, and calcareous; occasional sandstone beds. |
| 1,340–1,420 " | Soft, red shale, calcareous and becoming sandy at bottom. |
| 1,420–1,500 " | Soft, red sandstone with some shale. |
| 1,500–1,520 " | Sandy shale, red. |
| 1,520–1,680 " | Soft, red shale with sandy layers. |
| 1,680–1,750 " | Soft, red sandy shales. |
| 1,750–1,765 " | Sandstone, soft, red. |
| 1,765–1,790 " | Soft, red shale. |
| 1,790–1,810 " | Sandstone, soft, red. |
| 1,810–1,860 " | Sandy and gravelly shale. |
| 1,860–1,910 " | Sandstone, somewhat shaly at bottom. |
| 1,910–1,920 " | Soft, red shale. |
| 1,920–1,940 " | Sandstone, soft, red calcareous. |
| 1,940–2,025 " | Soft, red shale. |
| 2,025–2,044 " | Soft, red sandstone. |

'This well was terminated at a depth of 2,044 feet on account of the heavy water supply encountered, and of the constant caving in of the sides of the hole due to the soft nature of the rocks.

'It was cased with 13 inch pipe to a depth of 424 feet; with 10 inch pipe to a depth of 907 feet; with 8¼ inch casing to the depth of 1,418 feet 8 inches; with 6⅝ inch casing to a depth of 1,787 feet; with 5⅝ inch casing to the depth of 1,993 feet, from which depth the hole was finished with a 5 inch drill.

'Seams of water were encountered in the hole at various depths as follows:—

| | |
|---|---|
| At 30 feet | A heavy flow of hard water rising to within 4 feet of the top. |
| 210 " | Water still fresh. |
| 260 " | " |
| 390 " | " |
| 410 " | The above was cased off. |
| 460 " | Water in moderate amount. |
| 520 " | Water rising in hole. |
| 550 " | Water steadily rising, still fresh. |
| 630 " | Water still rising and fresh. |
| 670 " | Water risen to within 75 feet of the surface. |
| 690 " | Water still fresh but stationary as to level in hole. |
| 770 " | Water still fresh. |
| 890 " | Water brackish. |
| 930 " | Water during cessation of operations over Sunday rose to within 150 feet of top, but was bailed out on Monday. |

| | |
|---|---|
| 990 feet | Water harder to keep under. |
| 1,010 " | Water supply too heavy for bailing; drilling continued under water. |
| 1,090 " | Water up to about 150 feet from surface. |
| 1,430 " | Salt water encountered. |
| 1,640 " | Water still stationary at 150 feet from surface. |
| 1,770 " | Water above this all shut off by casing. |
| 1,810 " | A little salty water. |
| 1,880 " | Heavy flow of water. |
| 1,910 " | Water too heavy to keep bailed out. |
| 1,950 " | During Sunday water rose to level of 150 feet from surface. |
| 1,980 " | All water above this shut off by casing. |
| 2,030 " | Heavy flow of salt water rising to within 150 feet of surface and prohibiting further drilling. |

'*Log of well No. 4* (Boring Files No. 207), 1¼ miles from 'Little Sands,' Kings county.

'The log of the bore is as follows:—

| | |
|---|---|
| Surface to 25 feet | Sandy clay. |
| 25- 420 feet | Firm, red, shaly sandstone. 'The drillings show small fragments of pebbles of conglomerate, several hundred feet of which are exposed in the vicinity, dipping in such a direction that it must be drilled through in the hole.' |
| 420- 430 " | Bright red, firm shale. |
| 430- 442 " | Firm, red, shaly sandstone. |
| 442- 450 " | Firm, red sandstone. |
| 450- 520 " | Shaly sandstone, red. |
| 520- 540 " | Conglomerate of coarse-grained sandstone. |
| 540- 580 " | Firm, bright-red shale. |
| 580- 680 " | Red, shaly sandstone. |
| 680- 710 " | Firm, red shale. |
| 710- 740 " | Coarse, red sandstone (conglomerate). |
| 740- 790 " | Shaly sandstone, red, and firm. |
| 790- 800 " | Red shale. |
| 800- 880 " | Red, sandy shale. |
| 880- 890 " | Coarse, shaly sandstone or conglomerate. |
| 890- 990 " | Shaly, red sandstone. |
| 990-1,020 " | Firm, red shale. |
| 1,020-1,100 " | Firm, red sandy shale. |
| 1,100-1,130 " | Firm, red shale. |
| 1,130-1,150 " | Shaly sandstone, red. |
| 1,150-1,170 " | Firm, red shale. |
| 1,170-1,190 " | Shaly sandstone. |
| 1,190-1,360 " | Firm, red shale. |
| 1,360-1,420 " | Firm, red, sandy shale. |
| 1,420-1,450 " | Sandstone, somewhat shaly. |
| 1,450-1,560 " | Shale, red. |
| 1,560-1,595 " | Sandstone. |
| 1,595-1,620 " | Shaly sandstone. |
| 1,620-1,640 " | Shale. |
| 1,640-1,660 " | Shaly sandstone. |
| 1,660-1,690 " | Sandy shale. |
| 1,690-1,720 " | Sandy shale. |
| 1,720-1,730 " | Shale. |
| 1,730-1,740 " | Sandy shale. |
| 1,740-1,760 " | Sandstone. |
| 1,760-1,770 " | Sandy shale. |
| 1,770-1,790 " | Shale. |
| 1,790-1,810 " | Shaly sandstone. |
| 1,810-1,820 " | Sandstone. |
| 1,820-1,830 " | Shaly sandstone. |
| 1,830-1,840 " | Shale. |
| 1,840-1,880 " | Shaly sandstone. |
| 1,880-1,885 " | Shale, sandstone. |
| 1,885-1,970 " | Shale, red and firm. |
| 1,970-1,980 " | Red, sandy shale. |
| 1,980-2,000 " | Red, shaly sandstone. |
| 2,000-2,010 " | Red, sandy shale. |
| 2,010-2,040 " | Firm, red shale. |
| 2,040-2,050 " | Shaly, red sandstone. |
| 2,050-2,082 " | Firm, red sandstone. |

Water was encountered in this well as follows:—

| | |
|---|---|
| At 35 feet | Large flow of fresh, hard water. |
| 150 " | Salt water here first noticed to affect the freshness of the water in the hole. |
| 200 " | Water quite saline; and level in well is affected by rise and fall of the tide. |
| 442 " | Above water cased off. |
| 450 " | Salt water encountered, but not enough to flood the well. |
| 540 " | Great flow of salt water in conglomerate or coarse sandstone—too much to handle with bailer; rises and falls with tide. |
| 890 " | Above cased off. |
| 910 " | Fresh water struck in this layer. |
| 950 " | Flow of water increasing and becoming too great to bail out; drilling continued under water. |
| 1,010 " | Water becoming brackish. |
| 1,140 " | Water decidedly saline. |
| 1,190 " | Water up to tide level. |
| 1,414 " | Above cased off. |
| 1,430 " | Fresh water in small quantity. |
| 1,560 " | Considerable flow of fresh water. |
| 1,610 " | More water. |
| 1,650 " | More water, too heavy to bail out. |
| 1,713 " | Above cased off. |
| 1,750 " | A little brackish water. |
| 1,820 " | Quite a large flow of brackish water. |
| 1,860 " | Large flow of brackish water too great to be bailed out. |
| 1,895 " | Above cased off. |
| 1,990 " | Moderate flow salt water. |
| 2,060 " | Heavy and increasing flow of salt water. |

'This hole was cased with 10 inch pipe to 890 feet; with 8¼ inch casing to 1,414 feet; with 6⅝ inch casing to 1,713 feet; with 5¼ inch casing to 1,895 feet.

'At the lowest depth, 2,082 feet, the pressure of the large flow of water was so great that drilling could not be continued.

'*Well No. 5* (Boring Files No. 208). Miminegash, near Ebbsfleet, Prince county,

'The log of this well is as follows:—

| | |
|---|---|
| Surface to 220 feet | Bright terra-cotta coloured, earthy looking shales. |
| 220– 370 " | Paler terra-cotta coloured, sandy shales. |
| 370– 410 " | Paler terra-cotta coloured shales. |
| 410– 440 " | Pale terra-cotta coloured, sandy shales. |
| 440– 470 " | Purplish, sandy shale. |
| 470– 515 " | Pale terra-cotta coloured, sandy shales. |
| 515– 540 " | Terra-cotta coloured shale. |
| 540– 730 " | Paler pink, sandy shale. |
| 730– 800 " | Coarse, grey sandstone. |
| 800– 810 " | Terra-cotta coloured, sandy shales. |
| 810– 840 " | Terra-cotta coloured, shaly sandstone. |
| 840– 950 " | Terra-cotta coloured, earthy shale. |
| 950–1,060 " | Grey, calcareous sandstone. |
| 1,060–1,140 " | Grey, soft shales, showing carbonized matter as a scum on top of the pumpings. |
| 1,140–1,340 " | Brownish-grey to grey, soft sandy shales. |
| 1,340–1,440 " | Grey, firm sandstones. Pumpings showing traces of 'carbonaceous matter.' |
| 1,440–1,490 " | Brown shale. |
| 1,490–1,560 " | Grey, firm sandstone. Pumpings show scum of carbonaceous matter. |
| 1,560–1,660 " | Brown, soft shale, lighter coloured at bottom. |
| 1,660–1,670 " | Grey, soft sandstone. |

'At this depth the hole had to be abandoned, the shale caving in and burying the tools.

'Fresh water was encountered in the hole at 230 feet; a very heavy flow, which rose to within 30 feet of the surface. At 460 feet a very heavy flow of fresh water was

again encountered, the previous flow having been cased off. This water finally rose to tide level. At 620 feet the water began to get brackish. At 871 feet the water was cased off, and a heavy flow of salt water was encountered at 960 feet, which rose to sea-level when the boring attained a depth of 1,020 feet. The upper water was cased off at 1,279 feet, but another heavy flow of salt water was met with at 1,350 feet, which by the time 1,470 feet of depth had been attained had risen to sea-level. At 1,470 feet the upper water was again cased off, but a further supply of very salt water was met with at 1,480 feet, rising to within 100 feet of the surface. This was cased off at 1,562 feet.

'Great difficulty was met with throughout the operations due to the heavy flow of water and to the constant caving of the brown shales where encountered, and the difficulty of drilling in this class of rock when the hole was full of water.

'In comparing the characteristics of the rocks passed through in the above-described borings, the detailed lithological descriptions do not give the broadly distinctive contrasts which are evident when they are compared with each other as a whole. A full series of samples taken at intervals of 10 feet is on file in the department, from the study of which certain general differences are evident.

'In holes Nos. 1 and 2 the general colour of the samples is brown-red—sometimes mottled with greenish grey and toned down to purplish. For the whole depth of holes Nos. 3 and 4 and the upper part of No. 5 to a depth of about 950 feet, the samples exhibit a marked, bright terra-cotta red colour, toned down to purplish red in the sandy strata. In the lower portion of No. 5, grey to purple-grey, sandy beds predominate, with occasional recurrences of purplish-brown, shaly beds.'

Drill holes 2, 3, and 4 do not appear to have reached the bottom of the red beds of the Permo-Carboniferous.

No. 1, judging from the drillings, reached the lower grey beds of this formation at 1,890 feet, or 30 feet above the point at which the well had to be abandoned.

When I was searching for a site for No. 5 hole near Miminegash, it was noticed that the rocks contained strata not seen in the eastern part of the island, and that recrystallization about the sand grains was marked. This led to the hope that the surface rocks belonged to a lower horizon than those at the other bore-holes. Apparently this is the case, for the red beds extended to about 950 feet only, the remainder of the hole, to the bottom (1,660 feet), being in the lower, grey beds of the Permo-Carboniferous.

As there seemed to be a chance of getting into the Carboniferous with this hole, arrangements were made, through the kindness of Mr. Donkin, of the Mining Department of Nova Scotia, for a core drill to replace the churn drill when the water pressure would make it impossible to proceed farther with the latter. Unfortunately, before this point was reached, a heavy caving occurred, which buried the tools and the hole was lost.

Consequently, the Carboniferous has not been tested. But though the question of the extension of the coal basins from Cape Breton and Nova Scotia is still unsettled, it has now only an academic interest, so far as Prince Edward Island is concerned, since the work done has demonstrated that no coal occurs within commercial reach of the surface. The bore-holes average nearly 2,000 feet in depth, and have not reached the Carboniferous, which would have to be penetrated several hundred

feet before the Coal Measures would be encountered. The unstable nature of the rocks and their saturated condition would make sinking and maintaining a shaft a very difficult and expensive engineering feat.

No signs of oil or gas were obtained. The large column of salt water in the deeper levels makes it improbable that they should be found within a reasonable distance of the surface.

If, in the distant future, changed economic and engineering conditions should render the possibilities of oil, gas, and coal in the island a practical, commercial question, the pioneer work now done will furnish definite data upon which plans and estimates can be made, and the problem attacked in such a way that it can be conclusively settled.

While it is disappointing that no available mineral resources should have been discovered during this work on Prince Edward Island, it should be borne in mind that rarely in a limited area are rich agricultural and mineral resources associated, and of the two the island possesses in its agricultural land the more lasting and valuable asset.

## OIL PROSPECTS OF ALBERTA.

As the attention of the public has been drawn to the oil and gas possibilities of Alberta, and opinions of various officials of the Geological Survey have been quoted and misquoted, it may be well to outline the known facts regarding the possibilities, and the inferences to be drawn therefrom.

The geology of the northwest provinces is summarized by Dowling as follows:—[1]

'At the eastern edge of Manitoba, and extending northwesterly, appears the old Archæan plain on which, to the southwestward, are laid successive beds of Palæozoic limestones, in their turn covered by heavy deposits of shales and sandstones, mainly of Cretaceoeus age; though remnants of Tertiary deposits are found on this Cretaceous plateau. The Palæozoic rocks, which disappear under this mass of shales along its eastern edge, appear again in the Rocky mountains by faulting, and their load of softer rocks is there almost all removed, leaving traces only of the lower members in some of the valleys.

'The formations exposed in this part of the continent, therefore, range in age from the rocks of the Archæan complex, through the Palæozoic and Mesozoic to the Cenozoic. As before remarked, lying on the Archæan floor in Manitoba are exposed limestones correlated with the Ordovician and Devonian of other parts of the continent. These consist mainly of dolomitic beds that are flat lying, and form inconspicuous topographic features. In the Rocky mountains, in addition to this series, limestones and calcareous shales of Carboniferous age occur.

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[1] The Coal Fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Geol. Survey Publication No. 1035, pp. 19-27.

TABLE OF FORMATIONS.

| | Groups. | Alberta. | Saskatchewan. | Manitoba. | Montana. | Dakota. | Kind of Rocks. | Character of Fossils. | Economic Value. |
|---|---|---|---|---|---|---|---|---|---|
| Tertiary. | Miocene. Eocene. | Miocene. Paskapoo. | Miocene. | | | | Conglomerates and sandy clays. | Land and fresh water. | |
| | | | Laramie. | Laramie. | Laramie. | Laramie. | | | |
| | | Edmonton. | | | | | Sandstones and clays. | Fresh water. | Building stone. |
| Cretaceous. | Montana. | Bearpaw. | Pierre-Foxhill. | Odanah. | Foxhill. | Foxhill. | Sandstones and clays. | Land plants. Brackish water. | Coal. |
| | | Belly R. | Belly R. | | Bearpaw. Judith R. | Pierre. | Shales. Sandstones. | Marine. Brackish and fresh water. | Coal |
| | | Claggett. Eagle. | | Millwood. | Claggett. Eagle. | Pierre. | Shales. Sandstones. | Marine. Marine. | |
| | Colorado. | Niobrara. Cardium. | Niobrara. | Niobrara. | Niobrara. | Niobrara. Greenhorn. | Calcareous shales. | Marine. | |
| | | Benton. | Benton. | Benton. | Benton. | Benton. Graneros. | Shales. | Marine. | |
| | Dakota. | Dakota. | Dakota. | Dakota. | Dakota. | Dakota. | Sandstones. | Fresh water. | Some coal. |
| | Kootanie. | | | | | Fuson. Minnewaste. Dakota. | Sandstones and shales. | Land plants. | Coal. |
| | | Kootanie. | | | Cascade. Kootanie. | Morrison. | | | |
| Jurassic. | | Fernie. | | | Ellis. | Unkpapa. | Shales and sand-stones. | Marine. | |
| | | | | | | Sundance. | | | |
| Triassic. | | Banff shale. | | | | Spearfish. | Red shale. | Marine. | |
| Carboniferous. | | Banff lime. | | | Quadrant. | Minnelusa. | Limestone and quartzites. | | |
| | | | | | Madison. | Pahaspa. | | Marine. | Lime and cement. |
| Devonian. | | Intermediate Series. | Winnipegosan. | Manitoban. Winnipegosan. | Monarch. | | Limestone. | Marine. | Lime and cement. |

'The Mesozoic section is complete only in the vicinity of the mountains.

'The lower beds—red sandy shales—have been found north of the Saskatchewan to contain Triassic fossils. This red series is in turn covered by dark shales of marine origin, with fossils of a Jurassic type. They are everywhere found beneath the lowest coal measures, which are assigned to the Cretaceous, and form narrow beds running parallel to the ranges. No exposures of these Jurassic rocks are known east of the foothills.

'The lower Cretaceous consists of sandstones, and brown and black shales, in which are numerous coal seams. These rocks do not appear east of the foothills. The thickness of the formation increases westward, and is at its maximum in the Elk River valley, where it has a thickness of about a mile.

'The middle part of the Cretaceous, consisting of shales of marine origin, forms the plateau extending from the mountains to within the borders of Manitoba. The general topography, with its deeply incised valleys, is derived mainly from the erosion of these soft rocks.

'The upper part of the Cretaceous section, although for the most part marine shales, grades upward to sandy measures of brackish water origin. The harder beds of this upper part form many of the stronger topographic features, both of the foothills and plains. Few exposures are to be found in the mountains, where they have been almost entirely removed by erosion.

'The Tertiary rocks are . . . . . . sandstones with some shales and conglomerates. Exposures are to be found in the higher plateaus, such as Cypress hills and Wood mountain, and in the trough which extends north from the International Boundary in the foothills, including the Porcupine hills, and the sandstones at Calgary. The northern extension crosses the Saskatchewan west of Edmonton.

'The later deposits, such as the glacial till and the Saskatchewan gravel, will be but briefly mentioned. The glaciation of the mountains spreads a mantle of till through the foothills. The till of the Keewatin glacier does not always reach the eastern margin of the Rocky Mountain till, and they are possibly of two distinct periods. The eastern derived till is thin on the uplands, and often appears to have been rearranged by deposition in water. Morainic deposits occur on the Coteau in eastern Saskatchewan, and in Manitoba. Glacial lake phenomena have been observed at several parts; but the Lake Agassiz beaches of Manitoba, and the upper Red river, have formed the subject of several interesting reports.

*'Summary Description of Formations.*

*'Devonian—*

'In Manitoba, the Devonian rocks are divided into three series, Upper, Middle, and Lower.

*'Upper Devonian or Manitoban—*

'Light grey, hard, brittle limestone with red argillites at base; thickness about 200 feet.

*'Middle Devonian or Winnipegosan—*

'Light yellow, hard dolomite, with porous beds beneath; thickness about 200 feet.

'*Lower Devonian*—

'Mainly red shales; thickness about 100 feet. These beds probably represent only the upper part of the lower Devonian of eastern America.

'In western Saskatchewan these beds may be found near the Churchill river, having nearly the same characters.

'In Alberta, the most eastern exposure is in the neighbourhood of Athabaska river. In the Rocky mountains they form the Intermediate series, described by R. G. McConnell as being brownish, irregularly hardened dolomites, and greyish, crystalline dolomites, with some sandstones and quartzites.

'*Carboniferous*—

'As will be seen by the table, these rocks are found in South Dakota, Montana, and Alberta. They are not exposed in Manitoba nor along the northwest margin of the Cretaceous plateau, but are confined to the Rocky Mountain uplift. They have been subdivided on lithological characters into upper and lower Banff limestones. These formations are each capped by shaly beds, from which have been obtained a few characteristic fossils. The formation is generally a bluish limestone, and forms the summits of Cascade and Rundle mountains near Banff. A thickness of over 7,000 feet has been observed for the formation in the Bow valley.

'*Triassic*—

'A series of red, sandy shales, capped by a thin bed of yellow dolomitic limestone, exposed along the western slopes of many of the ranges, occurs at Banff, and has been called the upper Banff shale. Few fossils could be found at this locality in these measures; but in their continuation north to the Brazeau, several shells resembling *Monotis* help the correlation with the Triassic rocks of the Peace and Pine rivers. South of the Kootenay pass these rocks are associated with a volcanic trap outflow.

'*Jurassic*—

'*Fernie Shale*—

'In the locality where this formation received its name—near Fernie, B.C.—it consists of a series of black and brownish shales, 1,060 feet in thickness, overlying 500 feet of sandy argillites. Eastward, through the Crowsnest pass, the series decreases in thickness, and at Blairmore, near the edge of the mountains, there are only 700 feet. On the Cascade river the section is 1,600 feet, and consists of black shale and grey sandstones, with an occasional limestone bed toward the base. In the Moose Mountain area—an outlier of the Rockies—the thickness is only 225 feet. The formation has been traced northward to the Athabaska river, and preserves its general black, shaly appearance. Few fossils have been obtained in these measures, but these are characteristic . . . . .

'*Cretaceous*—

'*Kootanie*—

'The lower member of this series of deposits is found resting upon the Jurassic in the Rocky mountains. In Manitoba it has not been recognized, and is supposed to have formed but a very thin sheet to the east. It is recognized in the southern part of Dakota, and in Montana. In the Rocky mountains the

base of the formation is a heavy bed of sandstone, which is succeeded by sandstones and shales containing many coal seams. The maximum deposition during this period was west of the axis of the Rocky mountains. In the Elk River escarpment the formation measures 5,300 feet. East of this, at Blairmore, it is reduced to 740 feet. North, near Banff, it has a thickness of 3,900 feet; and in Moose mountain, east of the main range, there are only 375 feet. Northward, on the Bighorn, the thickness is about 2,000 feet. It would seem that east of the mountains the formation was not of great importance, owing to thinning of the beds. The fossils of the formation so far described are plants—ferns, cycads, and conifers.

'*Dakota*—

'In the mountains, above the coal-bearing sandstone, occurs a series of conglomerates and sandstones that have a newer flora. The measures are not distinctly coal-bearing, though a few thin seams are found. Fresh water conditions during this deposition prevailed in Dakota and Montana, and probably along the western margin; but northward, on the Athabaska river, the Tar sands representing a period contemporaneous with the Dakota of Manitoba, have a marine fauna.[1]

'The thickness of the formation in Manitoba cannot be much over 200 feet. In the foothills a thickness of 150 feet seems to represent the formation; but westward, in the Elk River valley, a much greater thickness of coarser material is found.

'*Benton*—

'Dark grey, almost black, shale of marine origin. In Manitoba, the deposit is about 175 feet in thickness. In the foothills it is over 700 feet; but this undoubtedly includes the overlying Niobrara . . . . . . . . . . . .

'*Niobrara*—

'In Manitoba, the formation consists of grey calcareous shales, which are an upward continuation of the Benton beneath. The thickness varies from 130 to 200 feet, though it is apparently much thicker in places. The upper part is rich in calcite, and is used in making a common grade of cement in Manitoba . . . . .

'*Eagle*—

'In the foothills the only exposure that can be correlated with the Eagle sandstone of Montana is a thin 50 ft. bed of light coloured sandstone.

'*Claggett*—

'The 'lower dark shales' of Dawson, in the Milk River region of southern Alberta—marine in origin, and holding fossils which are mainly the same as in the Pierre—have, in that locality, been given a thickness of 800 feet. In Manitoba, the lower part of the Pierre—the Millwood shales—may represent this deposition . . . . .

'*Belly River*—

'The Judith River formation of Montana is found to continue north into Alberta, and to constitute there the beds already called 'Belly River.' No exposures occur east of Saskatchewan; but if the divisional line between the two

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[1] Ottawa Naturalist, Vol. XII, p. 37.

portions of the Pierre in Manitoba marks the horizon occupied by them, there may be found thin beds to the east of those known. The formation is represented in the north, on Peace river, by the Dunvegan beds. In Alberta it is described as consisting of two divisions: an upper, pale series; and a lower, yellow part. In the upper, brackish water molluscs are found, consisting mainly of fresh water deposits. The lower portion is distinctly yellowish in colour, and is mainly a brackish water formation.

'The rocks are sandy clays with shales and sandstones, and the total thickness of the formation seems to be 900 feet. The thickness of the part exposed in Alberta may be not far short of 900 feet, though it evidently thins out eastward.

'Coal seams occur in the upper or fresh water portion, and the fauna resembles very closely that of a Tertiary type in beds above . . . . .

'*Bearpaw—*

'The Pierre-Foxhill of the writers of the geology of Saskatchewan and Alberta is without doubt that portion of the Pierre which is above the Belly River formation; but since it has been shown that the typical Pierre embraced beds below this shallow water and land deposit, new names have been suggested by Messrs. Stanton and Hatcher—Claggett for the lower shales, and Bearpaw for the upper . . .

'In Manitoba, the upper part of the Pierre is called Odanah, and may represent the same time interval as the Bearpaw.

'*Edmonton—*

'The Laramie rocks of southern Saskatchewan are, over a large part, divisible into two distinct divisions. The lower one consists of about 150 feet of feebly coherent, greyish, and pure white clays, sandy clays, and sands with occasional beds of carbonaceous shales and lignites.[1] This lower unnamed part bears the same relation to the marine clays of the upper Pierre that the Edmonton of Alberta does, and is here correlated with it.

'In Alberta, the rocks of the southern part, described as Laramie, are divided into three divisions, and the lower part of the lowest member—the St. Mary River beds—is of about the same horizon as the Edmonton of northern Alberta. It is distinctly a series of light coloured clays and sands, and contains numerous coal seams. The deposits form a brackish water transition series between the marine clays of the upper Pierre or Bearpaw, and the Tertiary, or purely fresh water formation . .

'The thickness of the formation varies, but attains a maximum of 700 feet in central Alberta.

'*Tertiary—*

'*Paskapoo—*

'This series consists of fresh water deposits, generally of yellowish sandstones and bluish-grey and olive sandy shales. It embraces the upper part of the Laramie of southern Alberta and Saskatchewan, with a total thickness of about 5,700 feet. The remains of plants are numerous, and denote a flora of a temperate climate . . . . .

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[1] Annual Report, Vol. I, 1895, p. 67 C.

'*Miocene*—

'Isolated exposures of coarse-grained material deposited on the eroded surface of the Laramie (in northern Alberta the Paskapoo series) have been found to contain a considerable number of mammallian bones. These beds are characterized by the great quantity of waterworn pebbles derived from the quartzites of the Rocky mountains.'

From this general description, it will be seen that the Cretaceous rocks which underlie almost the whole of Alberta have as their basal member, where exposed on the plains, the Dakota sandstone, a porous rock and a suitable reservoir for oil. It, in turn, along its exposed (northern and eastern) borders at least, rests upon the Devonian, and is overlain by shales that would form an impervious cover which might retain any oil that found its way into the Dakota sands.

The Dakota sands are exposed along the Athabaska river and elsewhere in the north, where they are charged with tar to the extent of 12 per cent of the whole mass. The tar represents the residuum of petroleum which has escaped to the air along the exposed edges of the rocks. Natural gas and some petroleum are still escaping. McConnell[1] estimates the area of Tar sands seen by him to amount to 1,000 square miles, which with an estimated thickness of 150 feet, would give 28·4 cubic miles of Tar sands, or 6·5 cubic miles of tar, equal to 4,700,000,000 tons of bitumen. Of course, the Tar sands have not been fully explored. A large amount of oil has escaped, but it is altogether improbable that this process has gone on indefinitely and that all has been drained off, for the hardening of the oil to tar effectively seals the openings for escape, and only the area near the exposed edges is likely to have lost its oil content. That the distribution of oil is probably extensive, is indicated by the finding of tar in sands near the surface, far to the south, in the Edmonton country, apparently formed by the limited escape of oil from minor fractures in the rocks. Oil seepages also occur in southwestern Alberta, in South Kootenay pass, and the Flathead valley.

Southward from the northern edge of the Cretaceous, the covering of later Cretaceous formations over the Dakota sands becomes thicker. One of these formations, the Belly River, is thick and lens-shaped, and Calgary is just about over the centre of the lens. Most of the borings have been put down near the railways where, except in the east, the Dakota sands are far below the surface, and have failed to reach this, presumably, oil-bearing horizon. The best place to test is, of course, in the north, where the covering over the Dakota sands is thinner, and where the presence of oil is indicated by tar in the sands, yet the spot chosen should be far enough back to be beyond the influence of the leaks along the exposed edges. The Geological Survey put down three test holes, one at Victoria, one at Athabaska Landing, and one at Pelican rapids. The latter represented the best judgment of the Survey as to the location of a test hole. The two former, about 1,800 feet deep, failed to reach the Dakota owing to the great thickness of the cover at these points. Farther north, the Pelican well, at a depth of about 800 feet, reached the top of the Dakota and struck a tremendous flow of gas. Pushed 20 feet farther, it struck another heavy gas vein and some oil. The escaping gas froze the oil on the drilling tools and pre-

[1] Report on a portion of District of Athabaska, 1893, p. 65 D, G.S.C. Ann. Rep., Part I, Vol. V, 1900-1.

vented further progress, so that the Dakota sands were not proved as to their containing commercial reservoirs of oil. None of the wells sunk about Medicine Hat, Edmonton, or Calgary, have penetrated deep enough to test the oil possibilities. The two Calgary wells, sunk to 3,400 feet each, were still considerably above the Dakota, and separated from it by impervious shales, but here the upper Cretaceous rocks are exceptionally thick.

In southwestern Alberta, in the Pincher Creek district, oil is being prospected for in two areas, on the south branch of the south fork of Oldman river, and on Oil creek, a tributary of Waterton lakes. The Survey has done no recent work in this district, but in the first field the rocks are, so far as can be learned, Cretaceous. The rocks on Oil creek were regarded by Dawson as Cambrian, a view which Daly supports, but Dr. Walcott, of the Smithsonian Institution, believes them to be pre-Cambrian—corresponding to the Belt terrane of Bailey Willis. On Oil creek a green schist is exposed from which there is a seepage of oil. The oil has a paraffin base, is of excellent quality, and free from sulphur. The Pincher Creek Oil Company has two shallow wells in this shale which have not been shot. These yield ½ to 2 barrels of oil per day, according to information deemed reliable. As this shale outcrops at the surface, apparently over a fairly wide extent of country, it would seem that by sinking a number of shallow wells into it and torpedoing them to form catchment basins, a considerable quantity of oil might be collected from it. Three other companies are prospecting here: one has a well down 1,020 feet, which is stated to have yielded at the outset 300 barrels per day. A second well, at a depth of 1,170 feet, is estimated by the drillers to be capable of producing 25 barrels per day. These wells have not yet been shot. Three companies are prospecting on the south fork of Oldman river: one has three holes down, the deepest of which is reported to be down 1,400 feet.

These districts lie within the front range of the mountains. Some uncertainty as to the oil prospects of this section is introduced by the occurrence of heavy overthrust faults which may have allowed oil reservoirs that once existed to drain off. Outside the mountains near Pincher Creek, an anticline, parallel to the mountains, appears to exist. While this structure is favourable for oil reservoirs, the thickness of the upper Cretaceous rocks presents difficulties, and there is a possibility that the Fernie shales and Carboniferous rocks may extend out from the mountains and form an impervious blanket which prevented the oil from reaching the Dakota horizon. The driller should be prepared to go as deep as 3,500 feet, and the soft shales, etc., of the upper Cretaceous present many difficulties in such deep boring. At Calgary borings would probably have to exceed 4,000 feet to test the possibilities of the district.

Near Edmonton the thickness of the rocks above the Dakota is not definitely known, but it is probably considerably over 2,500 feet, as the holes at Athabaska Landing and Victoria, 1,800 feet deep, did not penetrate to the Dakota, and at both these points the thickness of the overlying formations is less than at Edmonton. In the vicinity of Pelican rapids a hole about 1,000 feet in depth is required. Eastward the Cretaceous also thins out, so that at Medicine Hat holes of 1,800 to 2,000 feet in depth would probably reach the Dakota.

Natural gas seems to be widespread and to be present in large quantities. Productive gas wells have been drilled in the east at Dunmore Junction, Medicine Hat, Stairs, Suffield, Langevin, Bassano, and Bow Island. The surface rocks belong to the Belly River formation, and the gas veins are encountered in sandstone bands in the Niobrara shales. The gas horizons are tapped at depths of about 700 and 1,000 feet.

The Dakota has not yet been penetrated, but will probably be prospected in the near future.

Farther west, at Bow Island, on the Crows Nest railway, a well over 1,900 feet deep, which was drilled last spring, gives a flow of gas reported to be 8,000,000 feet per day, with a rock pressure of 800 pounds to the square inch.

In the north, on the Athabaska, natural gas is escaping along the banks of the river. In the Pelican Rapids well, about 180 miles north of Edmonton, an enormous flow of gas was encountered at the top of the Dakota.

The presence of immense tar fields along the outcropping edges of the Dakota in the north; the occurrence near Egg lake and other points near Edmonton of Tar sands which seem to have been formed by oil escaping from fissures; the oil seepages from the disturbed rocks in the mountains of southwestern Alberta, and the heavy veins of gas encountered by boring in northern and eastern Alberta, warrant the belief that good oil fields may be found in Alberta. The best points to prospect would appear to be: in the south, near Pincher Creek (where it would be necessary to be prepared for deep drilling); in the east, where it would be reasonably sure that gas, at any rate, would be struck, or in the north at about the latitude of Pelican rapids, where test holes would not have to be deep, and where the Dakota is known to have had large supplies of oil. The neighbourhood of Pelican rapids would be far enough back from the outcropping edges to find sand that may not have been drained of its oil. The proposed railway to Fort McMurray would render this district accessible.

About Fort McMurray and north of that point, the Devonian is exposed without a Cretaceous cover. Although the oil, which formed the Tar sands of the Dakota, probably came from the Devonian, and although the Devonian almost everywhere in the Mackenzie valley is more or less petroliferous, there are no grounds for supposing that the Devonian would be a particularly favourable formation to prospect, for oil escapes so readily, and in this case is known to have escaped in such quantities that it is uncertain that commercial reservoirs have been retained. It cannot, however, be stated that an undrained oil horizon does not exist in it, but only that prospecting in it is a gamble. If oil were found in the Dakota about Pelican and some information gained as to its distribution, prospecting could be continued southward, in the districts where deeper drilling would be necessary, with the element of chance to some extent eliminated.

## KOOTENAY COAL IN NORTHERN ALBERTA.

Samples of coal, with accompanying fossils, were brought down by Mr. J. R. Akins, of the Dominion Lands Branch, from Smoky and Muskeg rivers, north of the Grand Trunk Pacific railway. From these it appears that a basin of Kootenay coal-bearing rocks occurs in this latitude. This is the coal formation which carries the

high grade bituminous and anthracite coals of the Crowsnest pass, and Bow River valley, and it is important to find it extending so far north. The points from which the samples were obtained are in the neighbourhood of lots 3 and 4, township 57, range 7.

The reports of the officials of the Survey concerning the more important features of their work during the year are herewith appended.

# THE WHEATON RIVER DISTRICT, YUKON TERRITORY.

*(D. D. Cairnes.)*

## INTRODUCTION.

The season of 1909 was devoted to mapping and geologically investigating a portion of southern Yukon, extending 5 to 7 miles on each side of Wheaton river, commencing 6 miles above its mouth at Lake Bennett, and continuing over 20 miles up stream. This tract flanks the Coast range of mountains on their eastern side; while its southern edge is from 12 to 15 miles north of the 60th parallel of latitude (the British Columbia-Yukon boundary).

During the summer of 1906 I surveyed and examined a portion of the Conrad and Whitehorse mining districts,[1] including Windy Arm and the mining properties in the vicinity, and the lower stretches of Wheaton river. Since this was completed, a large number of mineral discoveries have been made along this latter stream. Some are situated in the western part of the area described in the above-mentioned report; but the majority are farther west. In fact, promising showings are to be found in various places, nearly to the headwaters of the Wheaton. The belt investigated during the past season includes all the known promising mineral properties south of the Whitehorse Copper Belt, and east of Windy Arm and the White Pass and Yukon railway.

Claims have been staked in nearly all parts of the district surveyed this past season, and, in spite of the extremely small amount of assessment or development work of any kind that has, in most places, been performed, several properties present a very encouraging appearance. Considering how slightly the district has been prospected, it is somewhat remarkable that so many deposits of ore have been found; and it is improbable that the best, or more than a small portion of all the valuable deposits has yet been discovered.

As soon as transportation charges on the railway have been reduced, so that outfits and supplies may be obtained at a more reasonable cost, and ore and concentrates shipped out at a moderate rate, there can be little doubt that prospecting and mining will be stimulated, resulting in a number of these properties becoming important producers.

A base-line, about two miles long, was measured along a tangent on the White Pass and Yukon railway, commencing about half a mile north of Robinson. From this base a triangulation was carried over the district. The topography was filled in chiefly by the photo-topographic method, aided to some extent by plane-table traversing. This latter method was also employed in surveying all roads, trails, etc.

During the season, I was assisted by E. W. Banting, B.A.Sc., and W. A. Bell, who performed in an efficient manner the greater portion of the topographical part of the work. Mr. Bell also assisted, at times, in the geological work.

## GENERAL CHARACTER OF THE DISTRICT.

### Topography.

The district described in this report is included in the western portion of the Yukon plateau, and extends westward to the eastern edge of the Coast Range moun-

[1] Cairnes, D. D., Geol. Surv., Can., Report on a Portion of the Conrad and Whitehorse Mining Districts, Yukon Territory.

tains. This plateau province, which has been described in previous reports,[1] is strikingly developed along the Wheaton river. It is quite evident that the rolling expanse of almost featureless upland is a portion of a recently unlifted, and subsequently, deeply dissected, almost base-levelled surface. The general level of this elevated tract is from 2,500 to 3,000 feet above the main intersecting stream beds, or 5,750 feet above sea-level. Occasional monadnocks, or generally rounded hills, rise in places above the surrounding expanse of upland, and constitute the only considerable inequalities which subaerial erosive agencies have left to break the monotony of the planated surface. The geological formations have no relation to, and do not accord with, the land surface, the formations being, as shown farther on in this report, of various origins, ages, textures, attitudes, etc.

The walls of the main valleys are generally steep, forming almost perpendicular declivities at numerous points. This feature of the topography has been accentuated and produced, in some instances, by glacial action. The main ice masses occupied these depressions and were effectual in straightening them and planing the slopes, and in widening and lowering their floors; causing the valleys to be wide, deep, and steep-sided. The smaller tributary streams flow with gentle gradient in wide, shallow depressions, over the upland surfaces, but generally plunge suddenly over the edges, by a succession of falls, through ravine-shaped incisions, to join the main streams below.

Numerous well defined terraces, at various elevations up to 700 or 800 feet above the stream beds, extend along the Wheaton valley and along Partridge pass, Becker creek, and others of its main tributaries.

Below the Big Bend of the Wheaton, the river valley has an average width of about one mile. Above the Big Bend, however, it is generally only one-quarter to half a mile wide. The stream itself is still active, removing the glacial gravels, sands, clays, etc., which, at one time, filled the valley to a depth of several hundred feet. The river channel is exceedingly tortuous, the course of the stream being easily altered in these slightly resistant glacial materials. The valley walls rise abruptly 2,500 to 3,000 feet on each side.

## Flora and Fauna.

The district is but sparsely forested: trees and shrubbery growing principally in the valley flats, and seldom extending up the hillsides more than 700 or 800 feet above the main depressions. The only trees of any considerable size are the white spruce (*Picea alba*); black pine (*Pinus Murryana*); and balsam fir (*Abies subalpina*); the spruce being by far the most plentiful. Some good groves of the latter species, straight and well grown, were noted in the valleys, the trunks seldom being larger than 12 inches in diameter, 3 feet from the ground. Black pine is occasionally found interspersed with the white spruce, or at times forming separate groves, either in the valleys or on the hillsides. The balsam fir is generally on the slopes near timber line. The two latter varieties seldom have more than a 10 inch stump. Willow (*Salix*); dwarf birch (*Betula glandulosa*); aspen poplar (*Populus tremuloides*); balsam poplar (*Populus balsamifera*); and western balsam poplar (*Populus trichocarpa*); cover a considerable portion of the valleys, and are found on the majority of the sidehills up to an elevation of 4,000 feet above sea-level. The dwarf birch, in places, also extends to the main plateau line.

Several varieties of wild fruit were noted in the district: mossberries; high-bush cranberries (*Viburnum pauciflorum*); and low-bush cranberries, were quite plentiful

[1] D. D. Cairnes—Report on a Portion of the Conrad and Whitehorse Mining Districts, Yukon.

Summary Reports of the Geol. Survey Branch—1906, 1907, 1908.

in places, also black currants (*Ribes Hudsonianum*); red currants (*Ribes rubrum*); *gooseberries*; blueberries (*Vaccinium*); strawberries (*Fragaria cuneifolia*); raspberries, and Saskatoon berries (*Amelanchior florida*) were noted.

Moose and sheep are fairly plentiful in many localities, as are also black, and grizzly bears. Caribou are less often seen. Wolves, wolverine, beaver, otter, marten, and lynx, are somewhat common. Cross, black, and silver foxes are also occasionally found. Ptarmigan exist in great numbers on the higher elevations, and grouse of different varieties are fairly plentiful. Rabbits, which a few years ago were so abundant, are now very scarce.

The streams and lakes are generally well supplied with grayling and trout.

### Climate.

The climate of southern Yukon is similar to that of many districts in British Columbia and other northerly but prosperous mining camps of the world, and in actual mining few more climatic difficulties have to be overcome, here, than in localities farther south. All necessary outside and surface work in connexion with mining and similar industries may be continued at least six months in the year. Besides, on account of the very long days at this northern latitude, surface work may be performed during a considerable part of the summer by night as well as by day, without the aid of artificial light. The ground, in many places, is continually frozen to varying depths, but this does not interfere with mining operations, except while work is being done at or near the surface.

The rivers generally open early in May, but on some of the lakes the ice remains until the first week in June. Slack water stretches freeze over any time after the middle of October, but occasionally the rivers remain open until well on in November.

### Transportation and Communication.

Two wagon-roads have been built from Robinson, on the White Pass and Yukon railway. One leads to Gold hill, a distance of 20 miles,, and the other, which is over 30 miles long, extends up Wheaton river. From these and branch roads, which can readily be constructed, access can be had to all parts of the district, the different mining claims being from 12 to 35 miles distant from the railway. A road could also easily be built, if necessary, down the Wheaton valley to Lake Bennett, along the eastern side of which the railway has been constructed. There is also an exceptionally good grade for a railway, to near the headwaters of Wheaton river, from either Robinson or Lake Bennett. The White Pass and Yukon railway connects at Skagway with lines of boats sailing to Vancouver and Seattle.

## GENERAL GEOLOGY.

The geology of this district is somewhat complex, and many types of rocks are represented, including sedimentary, metamorphic, volcanic, and plutonic. Highly altered schists, gneisses, and limestones, as well as more recent andesites, have been extensively invaded by granitic rocks. This complex is overlain by Jurasso-Cretaceous sediments which have been intruded, and, in part, buried in turn by andesites, andesitic tuffs, eruptive breccias, granite and syenite porphyries, and basalts. Newer than all these is a widespread series of trachytes, rhyolites, tuffs, and breccias, which are hidden in places by superficial deposits.

TABLE OF FORMATIONS.

| | | |
|---|---|---|
| Quaternary | Superficial deposits | Gravels, sands, silts, clays, volcanic ash, etc. |
| Pleistocene and late Tertiary | Wheaton River volcanics | Rhyolites, trachytes, tuff, breccias, etc. |
| | Carmack basalt | Basalt and basalt tuffs. |
| | Klusha intrusives | Granite and syenite porphyries. |
| | Chieftain Hill volcanics | Andesites, tuffs, and breccias. |
| Jura-Cretaceous | Tantalus conglomerate | Chiefly conglomerates with some sandstones, shales and coal seams. |
| | Laberge series | Conglomerates, greywackes, sandstones, shales, etc. |
| Jurassic | Coast Range intrusives | Granites, granodiorite, and diorites. |
| | Perkins volcanics | Andesites and andesitic tuffs. |
| Lower Palæozoic or older | Mt. Stevens series | Schists, gneisses, and limestones. |

*Mount Stevens Series.*—The oldest rocks comprise a series mainly of chloritic, sericitic, and greenstone schists, schistose quartzites, limestones, and gneisses. The schists are chiefly fine-grained, greenish, cholritic rocks, varying in structure from highly fissile to but slightly schistose. The sericite schists are generally soft and friable, yellowish to greyish in colour, and finely foliated in structure. The greatest thickness of limestone beds occurs on Schist mountain, where they have an aggregate thickness of approximately 700 feet; the rock varying from white to bluish, and from subcrystalline to crystalline. The most prominent gneisses are fine-grained mica gneisses and coarsely crystalline rocks presenting the appearance of crushed gabbros. All these rocks, which are believed to be of lower Palæozoic age or older, have been much altered and plicated, and occur in the form of small isolated areas brought up as infolds in the newer rocks—chiefly in the granites. A considerable portion of the ores of the district occurs in the schists of this series.

*Perkins Volcanics.*—More recent than the Mount Stevens group is a very homogeneous series, the Perkins series, consisting chiefly of considerably altered, hard, fine-grained, dark-greenish, andesites and andesitic tuffs.

*Coast Range Intrusives.*—Invading both of the above-mentioned series are numerous outlying areas of the granitic rocks of the Coast Range batholith, believed to be of Jurassic age. These rocks are generally fresh and unaltered in appearance, predominantly greyish in colour, and under the microscope prove to be generally granodiorites. In places they are quite porphyritic—feldspar phenocrysts 1½ to 2 inches long having been frequently noted. The greater number of the quartz veins of the district are found in these granitic rocks.

*Laberge Series.*—Newer than the granites are the rocks of the Laberge series of Jurasso-Cretaceous age, which consist of shales, sandstones, greywackes, conglomerates, and breccias. These beds are similar to those seen along Lake Laberge and elsewhere in the Braeburn-Kynocks and Tantalus coal areas. Medium textured, greenish-grey, heavily bedded greywackes frequently alternate with fine-grained shales and slates. The conglomerates consist chiefly of volcanic materials, the component pebbles and boulders—which are as much as 6 inches in diameter—being usually firmly cemented together. It is in the greywackes of this series that the ores of the Union mines have been deposited.

*Tantalus Conglomerate.*—Resting conformably on the Laberge beds are those of the Tantalus conglomerate series, which have here an aggregate thickness of 300 to 400 feet. These conglomerates, etc., which are associated with all the bituminous and

anthracitic coals so far discovered in southern Yukon, have been described in the author's previous reports on this territory. The series consists chiefly of generally dark coloured, heavily bedded conglomerates, the component pebbles of which consist entirely of chert, quartz, and slate. Associated and interbedded with the conglomerates are a few beds of sandstone and shale, and coal seams. The sandstones are composed, chiefly, of the same materials as the conglomerates, but in a more finely-divided state. The shales vary from light grey to almost black, are generally thinly laminated, and grade into typical slates.

*Chieftain Hill Volcanics.*—Cutting all the above-mentioned formations is a series of mica-hornblende, and augite andesites, andesitic tuffs, breccias, etc. They occur in some places chiefly as dikes, but in others form quite extensive sheets and flows. They vary from mica andesites, with greenish-grey to reddish ground-mass, in which are well defined plagioclase and biotite phenocrysts, to fine textured, dark green basaltic-appearing augite andesites. They correspond to, and include the members of, the Schwatka and Hootchi series of the Braeburn-Kynocks and Tantalus coal areas; but the characteristics that served to distinguish these formations in these latter localities are not here in evidence.

*Klusha Intrusives.*—Newer than these andesites are numerous dikes of granite and syenite porphyry, from 4 or 5 feet to several hundred feet wide. These are generally light grey, coarsely crystalline rocks, and correspond to the 'Klusha Intrusives' of the Lewes and Nordenskiöld Rivers coal districts.

*Carmack Basalt.*—Dikes and sills of a medium textured, dark coloured basalt, occur in numerous places, and cut all the above-mentioned formations. This basalt is similar to that seen to the north, in Miles cañon, and at other points in the vicinity of Whitehorse, also in the Tantalus coal area, farther north, and has, in the latter district, been included in the 'Carmack Basalts.' These rocks and the Klusha intrusives are considered to be of late Tertiary age.

*Wheaton River Volcanics.*—The most recent consolidated rock formation of the district consists of a series of trachytes, rhyolites, tuffs, breccias, etc. These are prevailingly light yellow in colour, becoming reddish in places owing to the oxidation of small particles of iron pyrites. They are generally soft, and weather and decompose readily, breaking, as a rule, into thin slabs. The mountain slopes on which these rocks outcrop—when seen from a distance—are bright yellow or red in colour, and are invariably covered with talus.

*Superficial Deposits.*—The main valleys in this district are floored with glacial deposits, which generally reach well up on the hillsides, extending in places even to the higher elevations. The channels of the main streams are entirely in these gravels, sands, tilts, etc., insufficient time having elapsed since their deposition for the water to remove them from these depressions. In fact, some of these principal pre-glacial waterways are still completely filled with such material. Overlying these Pleistocene deposits are more recent accumulations, composed of fluvial and littoral sands, gravels, and silts of the present waterways; muck, volcanic ash, and soil. The volcanic ash, which has been mentioned in nearly all reports on any portion of southern Yukon, is a notable feature in this district, consisting of a single, very evenly distributed and widespread layer, which is 3 to 6 inches thick along Wheaton river, and evidently due to one continuous, but short period of outburst. It is much more recent than the silts—the most recent of the glacial deposits; in fact, it is almost at the very surface, the grass roots extending down into it.

## ECONOMIC GEOLOGY.

With the exception of some coal seams found in one locality, this district, from the standpoint of economic geology, is of interest chiefly for its ore deposits. These might be arranged under three classes:—

(1) Quartz veins generally carrying galena, and in places, telluride minerals, chiefly sylvanite and telluric ochre. Arsenopyrite, zinc blende, pyrite, grey copper, bornite, chalcopyrite, malachite, azurite, etc., may or may not be present in small amounts.

(2) Fissure veins composed chiefly of stibnite with inferior amounts of zinc blende, in either a quartz or a calcite gangue.

(3) Contact deposits.

Deposits belonging to this last class have been found only on one property; but the veins occur in all parts of the district, those carrying antimony minerals being, however, limited to the extreme southwestern portion of the area.

The mining properties are here considered in order, from east to west.

## Union and Nevada Mines.

*The Union Mines* properties were located a number of years ago, and a general description of them has already been published.[1] They are situated on the east face of Idaho hill, and consist of three claims on which are a number of nearly parallel veins occupying fissures in a fine-grained, greenish-grey greywacke. The majority of the veins have a general strike of N 67° W,[2] and dip from 60° to 80° to the southwest. Ten veins in all were seen, having an average width of 4 inches to 12 inches; and others probably exist. The minerals are chiefly galena, arsenopyrite, zinc blende, pyrite, and chalcopyrite, and occur in a quartz gangue. Several veins from 8 inches to 10 inches thick, and highly mineralized with galena, arsenopyrite, and zinc blende, were noted. The thickest discovered is 2′-6″, and consists, on the surface, of decomposed material, chiefly quartz, pyrite, and galena. These ores generally carry some gold, but are chiefly of value for their silver and lead contents. All the work performed on these properties is of the nature of surface prospecting.

*The Nevada Mines* are a group of claims adjoining the Union mines. Several quartz veins showing some arsenopyrite, pyrite, galena, and zinc blende, have been found in them, and, to some extent, have been developed.

## Stevens Mountain Claims.

*The Buffalo Hump Group*, owned by Mr. Geo. Stevens, and consisting of the Sunrise, Golden Slipper, and Wheaton—all located on the north side of Stevens mountain—are probably the most widely known claims in the vicinity.

On the *Golden Slipper* claim, several hundred pounds of very rich quartz have been found, containing free gold and sylvanite. Although, when visited in August, the surface had been prospected somewhat carefully and a drift 85 feet long, with a 20 ft. cross-cut had been driven, the source of the high grade float ore had not been discovered. The formation is chiefly granite.

On the *Sunrise* claim is a 7 ft. quartz vein in a fissure in granite, which carries some galena and free gold. Little prospecting has been done here, hence it is not known, even approximately, how much gold and silver the average quartz carries.

On the *Acme* claim, owned by O. Dickson, is a lenticular quartz vein, in chloritic schist, the quartz being in one place over 30 feet thick. It appears, however, to be very slightly mineralized.

On the *Hawk Eye* group of three claims, owned by the 'Tally-Ho Boys,' and situated on the Wheaton River slope of Stevens mountain, are two quartz veins averaging 20 inches, and 3 to 4 feet, respectively, in thickness, which have been prospected to some extent.

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[1] Cairnes, D. D.—Report on a portion of the Conrad and Whitehorse Mining Districts, Yukon.

[2] All bearings in this report are astronomic, or true, the magnetic meridian being generally about 33° to the east of the astronomic.

On none of these claims on Stevens mountain has ore been found in place so far, rich enough to pay for mining. Still, extremely rich float has been found near the summit of the hill in several places; and from the size, angular character, and amount of the material, it is quite evident that it has come but a short distance, and belongs to the hill on which it is found; so that it is hoped that the vein or veins from which it is derived will be discovered.

### Big Bend Mountain Claims.

The *McDonald Fraction*, which is situated near the western edge of Big Bend mountain, is probably the best appearing prospect on this hill. Outcropping on it, and occupying a fissure in granite, is a 2 ft. vein of quartz, well mineralized, chiefly with argentiferous galena, which, it is claimed, contains gold and silver in very encouraging amounts.

The *Silver Queen and Gopher* claims are on the west side of Big Bend mountain, near the McDonald Fraction, and are the principal claims in a group of seven, owned by the 'Tally-Ho Boys.' On the former is a 3 ft. vein of quartz in granite, and on the latter in greenstone schist is a lenticular vein, which, at one point, is as much as 7 feet thick. These veins are reported to carry important amounts of gold and silver.

### The Tally-Ho Group.

On the west side of the Tally-Ho gulch, which extends along the western end of Big Bend mountain, the 'Tally-Ho Boys' have located eight claims. The development work, for this group, all of which has been performed on one claim, consists of a 250 ft. drift; a 10 ft. winze; a 40 ft. raise, and a cross-cut about 15 feet long. The ore occurs in a brecciated fault zone 4 to 5 feet wide in the granite formation, and consists of a quartz gangue impregnated with galena, the quartz varying in width from 2 inches to 4 feet. Of five assays of samples taken by the author, the average was close to $80 per ton in gold and silver.

### Becker Creek Claims.

On the east side of Becker creek, and on the west face of Anderson mountain, is a strong, well-defined quartz vein, 4 to 5 feet wide, contained in a fissure in granite. The strike of the vein is, approximately, N 68° W, and its attitude is nearly vertical. It can be traced nearly the entire length of the Rip and Wolf claims, and, in most places, is well mineralized with argentiferous galena. A basalt dike 2 feet wide has split the vein, and continues in it, for at least 2,000 feet.

On the *Rip* claim, owned by Wm. McGrew, a drift 90 feet long has been driven on the vein, the basalt dike in this distance crossing from one side of the ore to the other. The quartz obtained here should pay to work even under present conditions.

On the *Wolf* claim, owned by Messrs. Clark, Dickson, and Johnson, the basalt dike splits the vein into two about equal parts. Approximately 40 feet of open-cutting and drifting have been performed on this property.

The *Fleming* claim, located in July, 1909, by Mr. H. E. Porter, is situated on a small hill on the west side of Becker creek, and facing the Wheaton river. Here, certain beds of gneiss, which constitute a portion of the old pre-Ordovician series, have been more or less replaced by quartz, calcite, epidote, garnet, hematite, magnetite, pyrite, and chalcopyrite with its oxidation products azurite and malachite. The schists strike N 42° W, and dip at 60° to 70° to the northeast. To such a degree has the replacement proceeded that for a width of 30 feet, one schist band has been almost entirely altered to iron and copper minerals, with some epidote, quartz, etc. The 30 feet probably average about 1 per cent copper. Other similar but narrower bands were noted.

The origin of the ore is almost certainly directly due to the invasion of the granites which outcrop along the south side of the hill.

### Claims on Gold Hill and Vicinity.[1]

Considerable excitement was caused during the season of 1906 by the finding of quartz carrying free gold and telluride minerals on what is now the Gold Reef claim on Gold hill—midway between the Watson and Wheaton rivers, and 20 miles southwest of Robinson.

Since 1906, considerable development has been conducted on the *Gold Reef*; but only a few pockets, from the size of a man's head, to one of 500 or 600 pounds of the rich ore—which contains free gold, sylvanite, hessite, and telluric ochre—have been found: elsewhere, the vein, which is 4 or 5 feet wide, is almost barren, containing only occasional disseminated particles of pyrite, and but slight amounts of gold and silver.

Of the large number of other claims which were located in this vicinity in 1906, the only one on which any development work, other than assessments, has been performed is the *Legal Tender*. The vein on this property is in a fissure in granite, and is 3 feet to 3′-6″ thick, and consists of a quartz gangue in which are disseminated particles of argentiferous galena and chalcopyrite. The ore is claimed to have an average value of $40 per ton. A 100 ft. drift has recently been driven on the vein.

During a recent assessment on the *Lucky Boy* prospect, a quartz vein—at least 7 feet wide—was uncovered, which carries some copper glance, chalcopyrite, and malachite. As the vein is only stripped for a distance of 6 feet, very little information concerning it is available.

### Carbon and Chieftan Hills, and Vicinity.

A number of claims were staked on these hills during the season of 1893 by two prospectors: Frank Corwin, and Tom Kirkman; who, during the season, did considerable prospecting work on them. These men did not return again, and the ground remained vacant until rediscovered in August, 1906, by Mr. H. E. Porter, who located eighteen claims on the hills. This caused a general stampede to the vicinity, resulting in the staking of a great number of claims.

A large proportion of these claims, located during this rush, are still held, but on only a few has any work, other than assessment, been performed.

Mr. Porter and Mr. William J. Fleming, of Chicago, own three claims on Carbon hill, namely, the Porter, the Empire, and the Excelsior, which have recently been surveyed. On the Empire are the old workings—now caved in—of Corwin and Kirkman. On the Porter claim a drift is being driven to cross-cut a number of parallel veins, and when measured on August 20, was in 160 feet. The veins which are all in fissures in granite, strike about N 77° W. and dip from 40° to 50° to the northwest. The best appearing one of theses varies from 14 inches to 3 feet in thickness; can be traced over 200 feet on the surface, and has every appearance of extending much farther. The ore appears to be chiefly stibnite and sphalerite, in a quartz gangue. In places there are 12 to 14 inches of stibnite, with very little gangue mineral. Five feet below this vein is another, from 6 to 12 inches thick, and similar to the former, but not so highly mineralized. There are also two other veins within a few feet, which are from 2 to 6 inches wide, and consist of quartz with small disseminated particles of galena and grey copper, and, apparently, no antimony minerals. Samples from these two veins have assayed as much as $80 per ton in gold and silver. In a gulch on the north side of Carbon hill, Mr. Charles Goddell has located some claims on two parallel veins which are not more than 20 or 30 feet apart, and are exposed

[1] D. D. Cairnes—A Portion of the Conrad and Whitehorse Mining Districts, Yukon.

for over 2,000 feet. These strike N 80° W, have an almost perpendicular attitude, consist chiefly of quartz carrying some stibnite and arsenical iron, and are 2 feet, and 2 to 6 feet thick, respectively.

Besides the above-mentioned, a number of other veins from 6 inches to 2 feet thick, were noted. These are more or less highly mineralized, chiefly with antimony minerals, and occur, not only in the granite, but also in the overlying sedimentaries.

The two main claims on Chieftain hill are the Morning—owned by Messrs. Anderson and Eisenhauer; and the Evening—owned by Messrs. Dixon and Johnson. These properties are located on the same vein, which, near where it crosses Chieftain gulch, is 5 feet wide, and consists of quartz highly impregnated with stibnite; a portion of the vein—2 feet wide—being almost entirely composed of this mineral, which exhibits beautiful columnar and radiated structures. Fifty feet from this place, in each direction, the vein has narrowed to from 6 inches to 1 foot. This vein is in a fissure, in a fine-grained, greenish andesite; it strikes almost due east and stands nearly perpendicular.

## Bush Mountain Coal Area.

The Tantalus conglomerates which, in the southern Yukon, are known to be coal-bearing, were found outcropping about one mile west of the Union mines, on the ridge joining Bush mountain and Idaho hill, and search was made for coal, which, if found in this locality, would be of considerable value. Three seams were discovered: one over 6 feet, one 18 inches, and one of unknown thickness, but at least 3 feet. There were indications of other seams; but as the ground was frozen and the coal deeply covered, to have made a section of the measures, or even to have determined the thickness of the different beds of coal, would have entailed a very considerable amount of work. The measures were traced from the summit of the ridge to near the valley bottoms of Schnabel and Follé creeks on the south and north sides respectively. These creeks are here two miles apart, and, opposite the coal, are about 2,000 feet lower than the summit of the ridge between them. The belt of coal-bearing formation is about half a mile wide, and the rocks comprising it are much folded and disturbed. The coal, which is bituminous, and of the same age as that at Whitehorse and Tantalus, should make a good fuel.

## Quartz Claims East of Whitehorse.

After the close of the regular field season, a visit was made to certain quartz claims east of the Lewes river, near Whitehorse.

These claims are situated near the summit of one of the most southerly of the limestone hills in the range facing the town of Whitehorse on the east. The Lewes river, after flowing along the southern end of this range, turns suddenly at nearly right angles, and continues toward the north along its western face. Hence, the claims, being on the southwest corner of the range, are about equidistant from the river in either a southerly or westerly direction. They are about 8 miles in a direct line, or 12 miles by trail, in a southeasterly direction from Whitehorse; and the shaft on the Golconda claim is approximately 1,600 feet above the level of the town.

A good pack train, 7 miles long, has been built to these claims from Canyon City at the head of Miles cañon. Canyon City is situated on the east side of the Lewes river, on the opposite side of the river from, and five miles above, Whitehorse. A good grade is obtainable for a wagon-road from the claims to the river, either at Canyon City or other points above or below: the claims being nearest the river at points a few miles above Canyon City.

The claims themselves and the greater portion of the higher elevations in the vicinity are exceptionally well forested for this portion of the Yukon Territory. The principal timber trees are the white spruce (*Picea alba*), and balsam fir (*Abies salal-*

*pina*), the former being more abundant than the latter. Trees with 16 inch stumps were noted, and those with 14 inch to 16 inch stumps are fairly plentiful. The average, however, of the larger trees is not more than 10 inches in diameter, 3 feet from the ground.

There is also an abundant supply of water on the properties.

All the rocks seen on the claims and on the hills in the vicinity belong to the limestone series which outcrops so extensively along Tagish lake; in the neighbourhood of Whitehorse; along the Lewes river; and elsewhere in the southern Yukon. Although not positively proved, it has been supposed[1] that these rocks are of Carboniferous age. These limestones are, as a rule, very uniform, and generally appear as heavily bedded, subcrystalline rocks, varying from dark grey to almost white, but prevailingly light grey in colour. The chief impurities in them consist of small siliceous—at times cherty—aggregates. Rarely, beds of somewhat arenaceous or argillaceous material occur in the form of calcareous shales, and it is in a series of these that the quartz has been deposited, along which the Golconda group of claims has been located.

The Golconda group consists of four claims: the Golconda, Florence M., Concord, and Mohawk, all of which have recently been surveyed. The first two were located by Mr. Arthur Thompson in 1899, and are still owned by him. The other two have been located since and are owned by Mr. P. Campbell, of Whitehorse.

The quartz along which these claims are located occurs in a soft, friable, thinly-bedded, somewhat iron-stained, calcareous shale, which will often split into large flakes $\frac{1}{16}$ to $\frac{1}{8}$ inches thick. These shales have a total average thickness of about 100 feet, and are interbedded in the typical heavily-bedded limestones, which strike N 41° W and dip 40° to 50° to the northeast. Veinlets of quartz traverse these shales in all directions, the majority, however, following the bedding planes, and, in places, they become plentiful enough to form considerable masses of quartz. In places, a great part of the entire 100 feet is more or less invaded by these veinlets; individual stringers widening out occasionally to several feet thick. The greatest amount of quartz occurs near the centre of the shale belt, where for a width of from 6 to 26 feet it is almost free from rock; the material for a few feet on each side also consists to a greater or less extent of interlacing quartz stringers. This constitutes the Golconda vein, which can be traced the entire length of the four claims staked along it, which comprise the Golconda group.

The main group follows the general strike of the shale and limestone beds, and its dip appears to coincide with that of the enclosing strata.

The quartz, being much harder than the shales, weathers less readily, hence it stands out as a ridge from 4 to 12 feet high.

That the quartz is entirely confined to the shales and is not found elsewhere is, apparently, entirely due to the fact that, the solutions carrying the quartz found greater facilities for circulation through these soft, friable, thinly-bedded materials than through the more compact, heavily-bedded limestones. Moreover, the shales have, naturally, been more shattered, crushed, and broken than the stronger beds on either side; thus giving additional fractures and planes of circulation in the shale belt for the invading solutions.

Nearly all the work in this group has been performed on the Golconda claim, and consists chiefly of a vertical shaft, apparently 60 or 70 feet deep. The shaft may be somewhat deeper than this, however, as when it was visited it was impossible to see the bottom on account of water. A few small cuts, etc., comprise the remainder of the development work on the group.

Except close to the Golconda shaft the quartz is apparently entirely devoid of mineralization except for rarely seen particles of free gold and a slight amount of

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[1] G. M. Dawson—Report of Progress, 1887.

R. G. McConnell—Report on Whitehorse Copper Belt, Yukon Territory.

D. D. Cairnes—Report on Portion of the Conrad and Whitehorse Mining Districts, Yukon.

pyrite, which, in weathering, gives the quartz in places a somewhat reddish appearance on the surface. Close to the Golconda shaft the quartz contains some disseminated particles of chalcopyrite, and its oxidation product malachite.

It is claimed that assays as high as $40 a ton in gold have been obtained from this quartz. I made, however, two carefully taken, average surface assays: one at the top of the Golconda shaft, and the other from a place on the Mohawk claim, where some work has been done. Large samples were taken, and carefully quartered down. These were assayed by the Mines Branch, and in each case the result gave only traces of gold and copper. The Mohawk sample ran only a trace in silver; but the one from the Golconda claim gave 0·11 ounces silver to the ton.

It is possible that these samples do the properties injustice, as it is well known how difficult or next to impossible it is, in the case of a vein of free-milling quartz, to obtain a correct estimate of its value from the results of a few samples. A great many samples must be taken, and, when possible, a few tons of the material treated, before it is possible to decide as to its worth.

## WILLIAMS AND MERRITT CREEKS.

After completing the work in the vicinity of Whitehorse, a few days were spent on Williams and Merritt creeks, where recent copper prospects are attracting some attention.

Merritt creek empties into Lewes river on its left limit, five miles below Yukon Crossing; while Williams creek joins the river one mile farther down. These two creeks, for several miles from their confluence with the Lewes, have almost parallel courses, at practically right angles to this river. Yukon Crossing is about 155 miles from Whitehorse, measured along the Whitehorse-Dawson wagon-road, and 230 miles from Whitehorse, by the river, and is midway between Whitehorse and Dawson.

Merritt creek was formerly known as Merrice creek; and was so called after Homer Merrice, who discovered placer here in 1898. By a mistake, and believing it to be the original, the present name has been adopted. Williams creek is named after a prospector by that name, who was one of the first to locate on this creek in 1898.

During the season of 1898 these creeks were prospected for quartz and placer, for 25 miles from the Lewes river, and the old workings of this time can still be seen in many places. From then until 1907—when practically all the claims now being held were located—the district was unoccupied.

The only two rock formations which exist at all extensively in this district consist chiefly of granites and amphibolites. The latter are the older and are much altered, dark green, sheared eruptives, which consist chiefly of plagioclase and green hornblende, in nearly equal amounts. The schistose structure is generally quite pronounced; still, the rocks are practically never thinly foliated. The granites are generally greyish to pinkish, coarsely crystalline rocks. A thin section of a typical specimen examined under the microscope showed it to be composed chiefly of orthoclase, microcline, acid plagioclase, quartz, and biotite, with accessory apatite, titanite, and magnetite, and a great amount of secondary epidote and chlorite. In all probability, these granites belong to the series of granitic rocks composing the Coast Range batholith, which are generally considered to be Jurassic. The amphibolites lithologically correspond to certain pre-Ordovician rocks which have been studied in the vicinity of Dawson,[1] and elsewhere in the Yukon Territory.

The granites have invaded the amphibolites to such an extent that the outcrops of the two formations appear to be about equally extensive: tongues, dikes, and irregular-shaped masses of the former being found everywhere, where rock, in place, is to be seen.

[1] R. G. McConnell—The Yukon Gold Fields. Geol. Survey Branch, Canada.

The ore-deposits of this locality occur either at or near the contacts of these two formations, and are everywhere of the same character, consisting of veins of quartz impregnated with copper minerals, chiefly bornite, chalcopyrite, and malachite. Particles of free gold are also believed to have been found on one property. The only apparent reason for the quartz being always so near the contact is, that the mineralizing solutions which have deposited the ores have found easier places for circulation in these somewhat decomposed and fractured zones. The ores are apparently genetically connected with the granites, the ore-bearing solutions being an after effect of the intrusion of the granite mass.

The ores of the district are all of such a nature as to lend themselves readily to treatment by concentration.

All the claims and copper grants in the vicinity, on which any work has been performed, or on which any ore is known to have been discovered, were examined. The only ones, however, on which any considerable amount of ore was seen, or which, from their surface showings, give promise of being of value, are the Bonanza King, the Homestake, the Monte Cristo, and the Dawson. It is quite possible, and even probable, that there is a considerable amount of ore in this locality which has not yet been discovered, since the surface is, in most places, covered with superficial deposits.

The *Bonanza King* is situated about one mile from the Lewes river, on Nancy Lee creek—a tributary of Williams creek—joining the latter on its left limit. This property is one of eight claims comprising the Bonanza King group, owned by Messrs. J. Munroe, J. View, and M. H. Boulais. All the development work on the group has been performed on the Bonanza King and Dawson claims. The work on the Bonanza King consists of 150 feet of drifting and cross-cutting, and a 30 ft. shaft. The entrance to the drift is 250 feet above the level of the Lewes river, at the mouth of Williams creek; and the top of the shaft is 250 or 300 feet distant from the mouth of the drift, and 200 feet above it.

The shaft is sunk on a vein of quartz which is 6 feet wide at that point; but is lens-shaped and narrows rapidly in each direction. The vein is in granite, near its contact with the amphibolite, and carries considerable bornite, chalcopyrite, and malachite. Particles of free gold are also believed to have been found here. Two samples of the better mineralized portions of the vein, one taken near the surface and the other about 15 feet from the surface, were assayed, and gave, respectively, the following results:[1] (1) gold—trace; silver—trace; copper, 3·29 per cent; (2) gold—trace; silver—trace; copper, 4·21 per cent.

The vein in the drift occurs in the contact between the granites and amphibolites, and, where first encountered, is wider than elsewhere observed, having a width of 5 feet. It narrows to a few inches in a distance of 20 feet, in the direction in which the drift has been run. It was found, however, on the surface on a level with the drift, and at a distance of 50 feet from where first cross-cut, and has here a thickness of 3 to 4 feet.

Both the vein at the shaft and the one in the drift strike approximately in the same direction: N 45° W, but are not connected with each other. It is possible that other similar deposits exist along this contact, either between the two already found, or farther to the northwest.

The formation has here been considerably shattered and broken. One very prominent fault plane, indicating a displacement of considerable magnitude, was noted in the cross-cut and drift, having a strike about parallel to the strike of the veins. So that the faulting will serve to further complicate the working of these deposits.

An average sample of the 5 feet of quartz in the drift was assayed, and gave the following: gold, 40 cents; silver, 0·30 of an ounce; copper, 1·56 per cent.

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[1] All assays given in this report were made in Ottawa by the Mines Branch of the Department of Mines, Canada.

On the *Dawson* claim a 40 ft. drift has been driven on a quartz stringer in the amphibolites near their contact with the granite. The quartz, at the surface, was only 2 inches or 3 inches wide, but at the end of the drift was 18 inches. The ore is very similar to that on the Bonanza King.

On the *Monte Cristo* claim, which is also on Nancy Lee creek, and is owned by Messrs. Thompson and Granger, a vein has been discovered which, where exposed, has a thickness of 5 feet. Within a few feet of this are several parallel stringers a few inches wide. The vein filling consists chiefly of quartz, bornite, chalcopyrite, and malachite. The surface is covered, nearly everywhere in this vicinity, with drift and the products of weathering and decomposition, making prospecting very difficult; so that the chances of finding ore, at all, are but slight, even though there were a number of valuable veins on this and the adjoining properties.

An average surface sample of this 5 ft. vein was assayed, and gave as follows: gold, 20 cents; silver, 0·20 of an ounce; copper, 1·00 per cent.

The *Homestake* is one of six copper grants of 160 acres each, located on Merritt creek, and owned by Messrs. C. L. Johnson, Chas. Seagam, and I. B. Sanburn. The development work for the group has all been performed on the Homestake grant, which is located on the south side of Merritt creek, two and a half miles from the Lewes river. The valley of the creek at this point is 300 feet above the average level of the river, at the creek mouth, and the main workings of the property are about 150 feet above the creek bottom. There is a good grade for a road to this property, from the river, up Merritt creek.

The widest vein found on this property, and on which nearly all the development has been expended, is 6′–6″ wide, where it outcrops on the surface. A drift has been driven on it, which, including several cross-cuts run off it, has an aggregate length of 155 feet. The vein in the drift has a width of from 12 to 55 inches, and is in the greenish schistose rocks near their contact with the granite formation. Besides this main vein, other stringers up to 10 inches wide were encountered in the drift and cross-cuts.

The formations along the face of the hill have been considerably shattered and faulted, causing the veins in the drift and elsewhere in the vicinity to be often broken, rendering the working of them somewhat difficult.

The main vein in the drift strikes about N 83° E, and dips to the northwest at 45° to 55°. Outcropping along the face of the hill, and a few feet below the drift, is a connected series of elongated quartz lenses whose maximum width is 3 to 4 feet; which is traceable for over 200 feet, and strikes N 42° W, the lenses usually dipping at 80° to 85° to the northeast.

Higher up the hill four other veins have been uncovered, having, where exposed, widths of 14 inches, 16 inches, 2 feet, and 3′–6″, respectively.

The wider veins are often of a composite character; consisting of a zone of amphibolite, along the foliation planes of which, more or less quartz has been introduced. In the drift, where it is widest, the vein consists of a number of layers of schistose rock alternating with tabular masses of quartz, the two being in about equal amounts. In places, however, along this vein, and along others on this and neighbouring properties, the greater part of the quartz in a cross-section occurs in a single mass or lens; the lenses are, occasionally, connected, forming practically continuous veins for considerable distances.

An average surface sample from the 6′–6″ of quartz above the drift was assayed, and gave: gold, 20 cents; silver—trace; copper, 0·28 per cent.

An average sample was also taken of a number of large pieces of the better grade of ore from the different surface exposures on the Homestake property. This assayed: gold, $1; silver, 1·30 ounces; copper, 0·92 per cent.

The solid rock formations on the Homestake and neighbouring grants are nearly everywhere covered, and the finding of the quartz has been generally due to some such

fortunate accident as the finding of particles of quartz attached to the roots of an overblown tree. Since quartz has been found at so many points, with little bed-rock visible, it seems quite probable that a large number of veins would be exposed if the mantle of superficial materials could be removed.

# THE SKEENA RIVER DISTRICT.

*(W. W. Leach.)*

## INTRODUCTION.

The construction of the Grand Trunk Pacific railway from Prince Rupert eastward towards the Yellowhead pass is now well under way, and in consequence, much interest has been developed in the country through which the line will pass.

The activities of prospectors have been confined chiefly to those districts immediately tributary to the main line of the railway, with the result that, in the last few years, numerous promising discoveries have been made, including silver-lead, copper, and coal deposits. These now await the completion of the railway, when, with adequate transportation facilities (at present lacking), the owners of the various claims will be enabled to develop their properties at a much less cost than is at present possible. Until railway transportation is available most of the metalliferous deposits and all of the coal properties must of necessity lie idle or, at best, work on them must be confined to mere prospecting.

During the past year much attention has been paid to the silver-lead veins on Ninemile mountain, close to Hazelton, which previously had been overlooked; the mineral deposits and coal fields of the Telkwa river and Babine mountain being heretofore the centre of attraction.

A number of prospectors penetrated into the country lying north and east of Ninemile mountain, and many silver-lead claims were staked; while on Babine lake a few copper locations were recorded. No analyses have been made this year, by the Department, of any ores from this district; but, judging from the assays shown to the writer by the owners, a number of the silver-lead properties are well worth developing.

Several new coal areas at widely separated localities were briefly examined, but none of them appeared to be of great importance; though more detailed work may, in some cases, prove the existence of better seams than have been so far uncovered.

Field work was carried on from the end of May until the middle of September, but an exceptionally wet and cold season, unfortunately, seriously impeded progress.

From a measured base-line a system of triangulation was begun, and connected with the system carried on in previous years in the Bulkley valley, to the south, which extended as far as the headwaters of the Morice river. With this triangulation, combined with a road traverse through the Bulkley valley and other minor surveys, nearly sufficient material is on hand for the compilation of a map extending from Hazelton, on the Skeena, to Pleasant Valley, at the junction of the Morice and Bulkley rivers. A number of fossils collected during the past two seasons have been cursorily examined by Mr. Lawrence Lambe, of the Geological Survey, the ages given to the various formations being based on his determinations.

### Location and Area.

The greater part of the season was spent within a radius of 20 miles from the town of Hazelton, situated on Skeena river, at the mouth of the Bulkley, and the chief distributing point for all the country drained by these rivers, as well as for the placer camps on the Finlay, Omineca, and Manson waters to the east.

At present Hazelton is reached by river steamers from Prince Rupert (about 180 miles distant) during the short summer season of navigation; or by pack trail from Quesnel, on the Cariboo road, a long journey of about 350 miles. The completion of the Grand Trunk Pacific, however, will afford direct communication by rail.

## Previous Work.

This district has been, for many years, on the main trail to the old placer diggings to the east, though but little attention was paid to the country immediately tributary to Hazelton. Dr. Dawson briefly reviewed the geology in his report on 'An Exploration from Port Simpson to Edmonton' (Report of Progress, 1879-80), and Mr. Wm. Fleet Robertson, Provincial Mineralogist for British Columbia, paid a hurried visit to the mineral properties of the Telkwa in 1905 (Report of Minister of Mines, British Columbia, for 1905). These reports, with the Summaries for 1906, 1907, and 1908, and the preliminary report on 'The Telkwa River and Vicinity' by the writer, represent virtually all that has been written on this country.

## Summary and Conclusion.

The geological conditions obtaining in the districts traversed during the past season, vary little from those described in previous summary reports, with this exception, that the rocks there attributed to the Porphyrite group,[1] represented on the Telkwa by a great thickness of volcanics (tuffs, agglomerates, andesitic flows, etc.), are, apparently, gradually replaced to the north by sediments largely of volcanic origin, but towards the top consisting of shales and sandstone.

The occurrence of mineral-bearing lodes appears to depend upon the presence of eruptive areas later than the Hazelton group. This is exemplified on Twentymile, Ninemile, and Sixmile mountains, where three comparatively small granitic areas have numerous mineral claims located around their peripheries. It seems, therefore, important that prospectors should examine closely the neighbourhood of any such intrusive areas.

The coal-bearing beds overlie those of the Hazelton group, and are readily distinguishable from them in the Telkwa River region, but to the north, in the vicinity of Hazelton, the difference is not so marked. The coal beds, wherever seen, lie in comparatively shallow synclines; the overlying rocks being so soft that they have offered little resistance to erosion. Coal has been found in many places between the Morice and Kispiox rivers, in most cases only in small isolated areas of which few are of commercial value. In some cases, however, the acreage is comparatively large and the quality of the coal excellent.

Up to the present, coal prospecting has been carried on in a very crude, unsystematic manner, little or no attempt having been made to define the limits of the various areas. Before the boundaries of these areas are finally located, which will probably necessitate some method of boring, little idea of the true value of the properties can be deduced. In a number of cases the seams have already been proved to be of good workable thickness and of excellent quality.

### TOPOGRAPHY.

The district is, generally speaking, mountainous, but is intersected by a number of comparatively wide valleys; those of the Skeena, Bulkley, and Kispiox rivers, and Babine lake being the most important. They contain a large area of fertile land which has attracted many settlers during the past few years.

[1] The name, Porphyrite group, a descriptive term objectionable on this account and, as regards the district now being described, a misnomer, is replaced by a new name, the Hazelton group.

The mountains in many places are high and rugged, reaching elevations of over 8,000 feet, but are usually found in irregular, isolated blocks rather than in definite ranges, the mountain masses being separated from one another by low, wide passes. The most noticeable examples of this structure are the Rochérs Deboulés, near Hazelton, and the Hudson Bay mountains to the south.

The larger valleys all show more or less well-defined terraces, and in many places the streams have cut through the ancient valley floors, forming secondary, narrow, cañon-like channels. This is well shown at Moriceton cañon, on the Bulkley, and the Kitseguecla cañon, on the Skeena, as well as at many other places.

## GENERAL GEOLOGY.

By far the largest area in the district is underlain by rocks of the Hazelton group; or, as named by Dr. Dawson in his report on the Français Lake district to the south, and his exploration up the Skeena river; the Porphyrite group. This latter name was used by the writer in previous summary reports, as it appeared appropriate to the rocks of the Telkwa country, then under investigation. In the neighbourhood of Hazelton, however, it would appear that this designation might prove misleading, as there seems to have been from south to north a gradual transition from rocks of purely volcanic origin (chiefly porphyrites) to aqueous deposits such as those on Sixmile and Ninemile mountains, near Hazelton.

These rocks are overlain conformably by the coal-bearing beds which represent the youngest sedimentaries definitely known in the district; although it is very possible that some small Tertiary outliers may have been overlooked.

From a metalliferous miner's point of view, probably the most important geological factor is a series of granitic areas, younger than either the Hazelton group or the coal-bearing beds, and around which most of the mineral locations have been made.

### TABLE OF FORMATIONS.

| Age. | Name. |
|---|---|
| 1. Tertiary ? | Bulkley Eruptives. |
| 2. Lower Cretaceous | Skeena Series. |
| 3. Jurassic | Hazelton Group. |

## Description of Formations.

The terms 'Bulkley Eruptives' and 'Skeena Series' are here used for the first time, but in reading this in connexion with previous reports no difficulty should be experienced in identifying them, under this nomenclature, with the rocks described heretofore.

*Bulkley Eruptives.*—The eruptives met with during the past season are very similar to those noted in previous years on the Telkwa river and Hudson Bay mountains. A number of small areas were seen, notably on Twentymile, Ninemile, and Sixmile mountains, in no case of great size (probably none of them exceeding 1½ miles in greatest diameter), but, on account of their relationship to the ore bodies, of much importance.

These rocks have not yet been microscopically examined, but, generally, are granitic in appearance, often coarse grained, with much biotite and quartz developed, and vary greatly in colour and texture. Towards the contact they become in places porphyritic, and have caught up and apparently assimilated, to a greater or less extent, masses of the surrounding rocks, forming a zone in which it is difficult to define their boundaries. In colour they range from a light pink to a medium grey.

Practically all the known ore bodies are closely associated with these eruptive areas, the ore occurring either along the contacts or in, and alongside of dikes and fissures within a short distance of them. Nothing definite is yet known as to the age of these rocks. They are provisionally placed in the Tertiary, but may be older.

*Skeena Series.*—The Skeena coal-bearing series is met with in many localities, but as a rule in small patches. These appear to be the remnants of one or more great coal fields which, owing to the soft nature of the beds, have been unable, except in protected places, to resist erosion. The lower members of this series consist chiefly of conglomerates and coarse sandstone overlain by thin-bedded, shaly sandstones, nodular shales, and coal seams. Above the coal, shales are the predominant rocks, though in some places soft sandstones are found. There does not appear to be more than a few hundred feet of strata over the workable seams, except, perhaps, on the Morice river, where the denudation, to all appearances, was not so marked.

Small patches of these rocks are to be found at many places from the Kispiox to the Morice rivers, folded in with the underlying Hazelton group.

From a few fossil plants, collected during the past three seasons, it appears that these beds may be referred to the lower Cretaceous, about the horizon of the Kootanie series.

*Hazelton (Porphyrite) Group.*—The Porphyrite group consists, for the most part, of a great series of volcanics typically exposed on the Telkwa river and Hudson Bay mountains, and which have been described in previous reports. Northward and eastward from these localities, however, there appears to be a gradual passage from beds of purely volcanic origin to others of aqueous deposition but composed largely of volcanic material. At the top of the series fossiliferous sandstones and shales appear. The mountains to the north of Hazelton on both sides of the Skeena river are composed of rocks almost entirely of sedimentary origin, while the Rochérs Deboulés range, between the Bulkley and Kitseguecla rivers, is largely built up of volcanic flows, breccias, tuffs, etc.

From the fossil evidence so far obtained, the upper beds of this group (sandstones and shales) appear to be equivalent to the Fernie shales of East Kootenay and Alberta, and the 'Lower shales' of the Queen Charlotte Islands series, now supposed to be Jurassic. No fossils have been secured from the lower part of the Hazelton group.

### ECONOMIC GEOLOGY.

The intrusive granitic masses of the Bulkley eruptives have everywhere played an important part in the deposition of ore bodies; all of the chief mineral claims visited being situated either near their contacts or in, or alongside of dikes from them.

The eruptives have also affected the coal areas to a large extent; not only have the coal seams in places been cut by dikes, but the coal usually becomes more anthracitic in character as the intrusive granitic masses are approached.

## Groups of Deposits.

#### COPPER AND SILVER.

The copper ores of the Telkwa and the silver-lead veins of the Hudson Bay mountains have been briefly described in the last two Summary Reports, and no new information was obtained in regard to them during the past season.

#### SILVER-LEAD.

The most important recent development has been the opening up of a number of silver-lead veins on Sixmile, Ninemile, and Twentymile mountains, north of Hazelton. At all these points the ore is of the same general character, the principal minerals being galena, arsenopyrite, stibnite, and zinc blende in a quartzose gangue. The veins

are not large, but are reported to be rich in silver. Only two assays have been made by this department, both of which show good silver contents. The gold values are small.

The veins occur as a rule either in fissures in a hardened sandstone near its contact with intrusive granitic areas, or in sheared zones in the granitic mass itself. In one case (the 'Era,' on Sixmile mountain) the ore appears to follow the line of contact between the two formations.

Up to the end of the season nothing but surface prospecting has been attempted, and, except from the 'Lead King,' no ore has been shipped. From this property about five tons of galena were taken from an open-cut, sacked and packed on horses down to Hazelton for shipment to a smelter.

## Description of Prospects.

*Jack of Hearts and Jack of Spades.*—Jack of Hearts and Jack of Spades claims are situated on Twentymile mountain. The ore appears to follow a bedding plane in altered sedimentary rocks, the foot-wall consisting of rusty, decomposed argillite, and the hanging-wall of hard silicified sandstone. The strike is about N 30° E and the dip 50° northwest. The little work done—consisting of a few small open-cuts—is situated in the altered sedimentaries, but the claims extend into a comparatively large area of intrusive granitic rock to the west. The ore is much decomposed, and consists of about 18 inches of zinc blende, seamed with thin bands of greyish-white, magnesian ankerite, and a little galena, with a small quantity of rusty quartz gangue.

*Silver Cup.*—This claim, included in a group of four owned by Messrs. Harris and Trainer, is located on Ninemile mountain, about 6 miles north of Hazelton. The ore occurs in a highly altered sandstone, in places approaching a quartzite, a short distance to the east of an important granitic area. Strike of vein is about N 30° E, with a dip of 73° southeast, while the country rock strikes S 55° W, and dips 15° northwest. Two open-cuts have been made on this claim, the lower of which shows both walls well defined and the vein 1·2 feet in width. The vein matter consists, at this point, of nearly solid galena, with a little stibnite, arsenopyrite, blende, and white quartz.

The following assays of this ore were shown the writer by Mr. Harris:—

| | No. 1. | No. 2. | No. 3. |
|---|---|---|---|
| Gold.. .. .. .. .. .. .. .. .. .. .. .. .. .. | trace. | trace. | trace. |
| Silver.. .. .. .. .. .. .. .. .. .. .. .. .. .. | 181·0 ozs. | 268·2 ozs. | 187·4 ozs. |
| Lead.. .. .. .. .. .. .. .. .. .. .. .. .. .. | 70·0 % | 50·0 % | 58·4 % |

(All by the Canadian Consolidated Mining and Smelting Company.)

The second cut lies about 200 feet farther south. Here the vein opens out, being about 2·5 feet in width; but the ore is not so solid, less galena being present; while there is more stibnite, and much more quartz.

*Silver Dollar.*—The Silver Dollar claim belongs to the same group as the last mentioned, and is opened by a cut about 2,000 feet south of those on the 'Silver Cup.' Similar conditions are found here, and it is possible that this is the same vein. The vein, where cut, is 3·2 feet wide, the ore consisting of milk-white quartz carrying disseminated crystals of arsenopyrite, a little stibnite, iron pyrites, and a very little magnetite.

*Hazelton.*—The Hazelton adjoins the Silver Dollar to the west, the geological conditions being similar. Near the eastern end of this claim a small vein has been cut which has a strike nearly at right angles to that on the Silver Dollar, viz.,

NOTE.—All bearings given are referable to the true meridian. Magnetic variation is about 30 degrees east.

S 70° E, with a nearly vertical dip. This vein is only 0·7 of a foot wide, with well defined walls; the country rock being a hard, altered sandstone. The ore consists of finely crystalline arsenopyrite associated with a little white quartz.

At the western end of the claim several open-cuts show a little ore. The rock here is much shattered and altered, being very near the granite contact. One small vein, 6 inches wide, was stripped, and here consists of white quartz with crystalline galena and a little brown zinc blende.

*Sunrise.*—Sunrise claim is one of a group of four owned by Messrs. Harris and Rosenthal, and is situated about one-half mile northeast of the 'Silver Cup.' The ore occurs in the granite, not far from its contact with the sandstones, and appears to follow a line of crushing and faulting. The vein strikes S 75° W, and dips to the south at an angle of 60° where opened by a cut. The foot-wall is well defined, smooth and slickensided, while the hanging wall is not so clearly shown and is much shattered and decomposed. In the cut the vein is 2·7 feet in width, and shows 0·8 of a foot of solid galena about the middle of the vein, the remainder consisting of quartz with disseminated galena and a little stibnite.

The following analyses from samples of the solid galena were handed to the writer by Mr. Rosenthal:—

| | Gold. | Silver. | Lead. |
|---|---|---|---|
| 1.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. | trace | 116·6 ozs. | 55·2 per cent. |
| 2.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. | " | 125·0 " | 75·5 " |
| 3.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. | " | 115·0 " | 65·2 " |
| 4.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. | " | 120·0 " | 75·0 " |
| 5.. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. | " | 115·0 " | 65·0 " |

(All by the Canadian Consolidated Mining and Smelting Company.)

About 300 feet to the west of this opening another vein has been stripped on this claim. The vein is 12 inches wide, and strikes east and west, dipping south 15°. The ore is an association of white quartz with a little white dolomite, carrying very small amounts of galena and zinc blende.

*Lead King.*—The Lead King mineral claim lies about one-quarter of a mile to the west of the Sunrise, and is situated in the granite near its contact with the sedimentaries. The granite here is much shattered, numerous small slickensided fault planes at all angles being in evidence; the ore apparently occurring along a line of weakness. The vein has been stripped at a point where it has been much disturbed, and it is doubtful whether the dip seen here can be considered as normal. In the cut the strike is east and west, and the dip S 22°. The width of the vein is 3·1 feet, the whole being heavily mineralized: the ore being an association of finely crystalline galena with some zinc blende, together with a small amount of weathered siliceous gangue.

As before stated, a shipment of about five tons has been made from this property for a smelter test, but as yet no returns are available.

*Era Group.*—The Era group of four claims is situated on Sixmile mountain, between Sixmile and Fourmile creeks, about 5 miles from Hazelton. A number of open-cuts have been made on the property, all of which show some ore. There appears to be a number of irregular veins developed along small fault planes and crushed zones in a small granitic area (this eruptive mass being distinct from that on Ninemile mountain). In one case, however, on the 'Era' claim, the ore appears to have developed along the contact of the granite and the sedimentaries; the hanging-wall consisting of highly metamorphosed sandstone and the foot-wall of granite. At one point on this contact an open-cut has been made, exposing 3·9 feet of ore, the strike being about northeast and dip 70° southeast. On the foot-wall the ore consists of white quartz with small quantities of disseminated galena, while on the hanging-

wall the mineralization is much heavier, there being from 18 inches to 2 feet of almost solid sulphides of antimony, lead, arsenic, silver, and copper, with a little white quartz gangue. It contains, also, a little free sulphur.

Two assays of this ore by the Mines Branch, are here given:—

| | Gold. | Silver. | Lead. | Copper. |
|---|---|---|---|---|
| No. 1 | 0·08 ozs. | 358·17 ozs. | 7·81 % | 0·75 % |
| No. 2 | 0·02 ozs. | 46·16 ozs. | 6·90 % | 0·26 % |

The samples also showed antimony and arsenic in considerable quantities.

## COAL.

*Shegunia River Area.*—The Shegunia river (Salmon river) coal area is situated on the east bank of the Skeena river, 2 or 3 miles above the mouth of the Shegunia. The limits of this basin were not traced out, but sufficient work was done to prove it to be of considerable extent. The strata, however, where exposed along the Skeena banks, are so highly flexed and faulted that it seems improbable that mining can ever be successfully undertaken unless further prospecting proves the seams to be in a less disturbed condition in other parts of the basin.

This property has been more or less prospected for some years, but never systematically. At present all that can be seen is an old shaft about 25 feet deep (now partly caved), a few open-cuts, and a cross-cut tunnel 35 feet in length which has not yet reached the coal.

At least three seams were noted, their relative position being somewhat doubtful on account of the disturbed nature of the strata. An approximate section of the coal beds, where the seams are stripped, is here given:—

| | | |
|---|---|---|
| | Grey shales | —— |
| 1. | Coal | 2·0 feet. |
| | Shales and sandstone | 75·0 " |
| | Black carbonaceous shale | 3·0 " |
| 2. | Coal | 2·1 " |
| | Sandstone and shale ..about | 50·0 " |
| 3. | Coal | 5·1 " |
| | Grey and carbonaceous shale | —— |

In all three seams the coal is very severely crushed, and in the case of seams 2 and 3 at least, is high in ash. Analyses of the two lower seams are as follows:—

| | Moisture. | Vol. Comb. | Fixed Carbon. | Ash. |
|---|---|---|---|---|
| No. 2 seam | 1·42 | 18·76 | 58·20 | 21·62 |
| No. 3 seam | 1·18 | 20·63 | 57·27 | 20·92 |

No. 2 seam, non-coking.
No. 3 seam, cokes.

*Babine Lake Coal.*—A hurried trip was taken to a reported new coal area on Babine lake. Four claims had been staked on the Tuchee river about 17 miles above its mouth. This stream flows into Babine lake from the west about 50 miles above the outlet, and drains most of the eastern slope of the Babine range.

On arrival at the claims, it was found that very little work had been done, and most of that had been obliterated by a small landslide. Without time and tools it was impossible to determine the extent of the area or the size and value of the coal seams. All that can be said in reference to these claims is, that the Coal Measures are present, and that one small seam (about 2 feet thick) of impure coal was seen. It is possible that other and better seams may ultimately be found underlying a considerable area, but much prospecting is necessary before the value of this property is determined.

The following analyses is from a sample of the above-mentioned 2 ft. seam:—

| | |
|---|---|
| Moisture | 2·55 |
| Vol. comb | 17·28 |
| Fixed carbon | 52·20 |
| Ash | 27·97 |

Does not coke.

Since this visit, the finding of seams of coal of fair width is reported.

*Morice River Coal.*—A new coal area was discovered late last summer on the Morice river, below those described in the Summary Reports for 1907 and 1908, and about 30 miles above the junction of the Morice and Bulkley rivers. As the season was rapidly drawing to a close, little time was available for examination of this basin. From a cursory visit, it would appear that there is quite an extensive area here underlain by the coal-bearing beds, but only one seam has so far been stripped, showing the following section:—

| | | |
|---|---|---|
| Grey shale | | feet. |
| Clean coal | 0·45 | " |
| Shale | 0·05 | " |
| Clean coal | 0·40 | " |
| Shaly coal | 1·20 | " |
| Hard, blocky coal | 1·40 | " |
| Grey clay shale | 2·00 | " |
| Coal | 0·80 | " |

Of the following analyses, No. 1 is from the lower bench (0·8 feet) and No. 2 from the cleaner portions of the upper part of the seam:—

| | Moisture. | Vol. Comb. | Fixed Carbon. | Ash. |
|---|---|---|---|---|
| No. 1 | 2·65 | 23·93 | 48·95 | 24·47 |
| No. 2 | 2·05 | 29·43 | 57·38 | 11·14 |

No. 1 is non-coking, and No. 2 cokes well.

It is to be hoped that future prospecting will bring to light some workable seams similar in character to No. 2, as up to the present time, as far as the writer knows, no satisfactory coking coal has yet been found in the Skeena River country.

## Manson Creek Hydraulic Mining.

Although referring to a property outside of the district covered this year by the writer, the following notes furnished by Mr. H. Beach, of the Kildare Mining Company, may be of interest.

The Omineca placer diggings have been worked for many years, chiefly by individual miners, the output of late years being insignificant.

The 43rd Mining Company, and their successor the Kildare Mining Company, have for thirteen years been prospecting their territory on Slate creek, with the object of starting hydraulic mining on a large scale. The difficulties of mining in this district are very great, everything having to be packed on horseback over a poor trail for about 200 miles from Hazelton. Seven or 8 miles of flume and ditch have been built, and a small prospecting plant installed. During last season bed-rock was reached in an old channel, and during July and the beginning of August about $10,000 in coarse gold recovered. This was accomplished with a force of 20 men and an inadequate plant. Work then stopped until proper machinery was installed, enabling the property to be economically managed.

Mr. Beach reports that there are from 25 to 30 feet of gravel above bed-rock, the whole of which he considers will average about $3 a yard.

Besides coarse gold, with many nuggets, the following metals and minerals were recovered in the sluice boxes: native silver, native copper, platinum, arquerite (native silver amalgam), iridium, and much galena.

## TEXADA ISLAND AND MORESBY ISLAND, B.C.

*(R. G. McConnell.)*

The work of the season consisted in completing the geological mapping and examination of the mines and prospects on Texada island, and in a hurried visit of seventeen days to some of the principal mineral districts on Moresby island, in the Queen Charlotte group. I was assisted in the Texada Island work by Mr. A. O. Hayes.

### TEXADA ISLAND.

The rocks and the principal mines and prospects occurring in the northern part of Texada island were examined in 1908, and briefly described in the Summary Report of the Geological Survey for that year. During the present season the work in the northern part of the island was completed, and the examination extended to the southern portion.

#### Topography.

The southern part of Texada island consists of a steep-sided rocky ridge rising directly from the sea, surmounted by occasional peaks, some of which reach an elevation of nearly 3,000 feet. North and west of Pocohontas mountain the general elevation decreases rapidly, and the surface, while still broken by occasional rounded eminences, such as Comet and Surprise mountains, becomes more even and in places assumes a plain-like character.

The island nowhere exceeds 6 miles in width, and the streams draining it are necessarily short and small. Many of them are intermittent, and only a few of the larger ones flow steadily throughout the year. Lakes, varying in size up to half a mile in length, occur at a number of points, mainly in the lowlands at the northern end of the island, but also occasionally in depressions on the slopes and near the summits of the higher elevations.

The greater part of the island is still well wooded, although a portion of the original luxuriant forest has been destroyed by forest fires or cut for commercial purposes. The principal tree is the useful Douglas fir. Other trees found with it include species of hemlock, pine, spruce, and cedar. The broad-leafed varieties are represented by the maple, arbutus, and alder.

#### Summary of Geology.

The rock formations of Texada island are not numerous, are mostly of igneous origin, and range in age from upper Palæozoic to middle Cretaceous. They have been classified as follows:—

| | |
|---|---|
| 1. Pleistocene | Boulder clays, stratified sands and gravels. |
| 2. Cretaceous | Soft sandstones, sands, clays, and shales. |
| 3 Lower Cretaceous or Upper Jurassic | Diorites and diorite porphyrites, dikes and small stocks. |
| 4. Upper Jurassic ? | Quartz diorites; referred to period of Coast Range batholith. |
| 5. Triassic ? | Porphyrites, Texada formation, Texada group of Leroy (in part). |
| 6. Upper Palæozoic | Limestones, Marble Bay formation. |
| 7. Upper Palæozoic | Schists, tuffs, agglomerates, marbles, etc. Anderson Bay formation, Texada group of Leroy (in part). |

*Anderson Bay Formation.*—The rocks of this group occupy a small area at the southern end of the island, and a narrow band extends northward for some distance along the east coast. They consist mainly of dark, light-greyish, and greenish schists and shales probably mostly of tufaceous origin, interbanded with agglomerates and occasional narrow lenses of crystalline limestone. They were nowhere found in contact with the limestones of the Marble Bay formation, and have been placed below them principally on acccount of their greater alteration.

*Marble Bay Formation.*—The Marble Bay formation occurs mostly in the northern end of the island, and was described in the Summary Report for 1908. It consists altogether of limestone usually whitened and crystallized near contacts with igneous masses. It originally extended southward over the greater portion of the island, but has been largely destroyed by the various intrusions of igneous rocks which followed its deposition.

*Texada Formation.*—The rocks referred to the Texada formation are widely distributed over the island from Crescent bay southward to Mount Dick, and form all the higher peaks and ridges. They consist altogether of porphyrites showing considerable diversity both in appearance and in the proportions of the constituent minerals. Normally the porphyrites are brownish weathering, medium to fine-grained, greenish or greyish rocks, made up of a ground-mass of plagioclase and varying quantities of augite, hornblende, and chlorite, sprinkled more or less plentifully with plagioclase phenocrysts which on the surface usually present a faded appearance. The ferromagnesian minerals seldom occur conspicuously as phenocrysts. The normal type passes in places into a fine-grained, compact, greenish rock, and more frequently into a medium-grained granular rock showing macroscopically only traces of the ordinary porphyritic texture.

Amygdular rounded and elongated cavities filled with quartz, calcite, and epidote, and lined with a dark chloritic mineral, occur sparingly in certain areas.

The porphyrites in many sections have a conspicuous nodular structure, and in places closely resemble, and were at first mistaken for, a volcanic agglomerate. The nodules are usually finer grained and harder than the enclosing matrix, and project on weathered surfaces. In shape, they vary from spheroids usually from 6 inches to 1 foot in diameter, to elongated, flattened, nodular masses 10 to 15 feet or more in length. The nodular porphyrite occurs in small and large irregular areas, separated by the normal uniform variety.

The nodules are similar in mineral composition to the enclosing matrix and the massive variety, and they probably represent the first centres of crystallization in the cooling magma.

*Quartz Diorites.*—The rocks referred to the quartz diorites occur mostly in small areas fringing the northeast coast along the central portion of the island. One area also occurs on the west coast at the Iron range, and one inland. The quartz diorites are mostly greyish granular rocks resembling granites, and were classed as granites in previous reports. The present classification is due to a study of a number of thin sections by Dr. Young, who described them as consisting essentially of plagioclase with varying and much smaller amounts of quartz and biotite accompanied by hornblende, or pyroxene, or both. A small quantity of orthoclase is also usually present, and magnetite is a constant accessory.

The quartz diorites are regarded as an extension westward across the Malaspina straits of the Coast Range batholith rocks of the neighbouring mainland.

*Diorites and Diorite Porphyrites.*—The rocks of this group occur in small stocks and in dikes distributed mostly over the northern part of the island. The stocks intrude the porphyrites and the limestones of the Marble Bay formation, but have not been found in contact with the quartz diorites. Some of the diorite stocks are younger

than the typical quartz diorites, as inclusions of the latter were found in one area; and dikes which occur as apophyses from the diorite areas are indistinguishable from dikes cutting the quartz diorites. The two groups are, however, closely related, and some of the stocks cannot be referred with certainty to either.

The diorite and quartz diorite stocks are important economically, as most of the valuable mineral deposits of the island occur either at or near their boundaries.

*Cretaceous.*—Cretaceous rocks occur on the west coast of Texada island in small isolated areas extending from Gillies bay southward to Cook bay. The areas were probably connected originally, and have been separated by erosion. The rocks consist of clays, shales, soft sandstones, and conglomerates. No coal or lignite beds were seen, and it is unlikely that any exist, as the series is well exposed in the valleys of the streams cutting the areas.

The porphyrite floor on which the Cretaceous beds rest is more or less decomposed, to a depth, in one instance, of 100 feet or more. The decomposed material occurs both in an unstratified condition filled with cores of the original rock, and sorted by water into beds of soft red clay and loose reddish conglomerate. The red clay beds are reported to contain about 13 per cent of iron, and may be of some economic value.

The Cretaceoeus beds show only slight disturbance, if any, are not cut by dikes or other intrusive bodies, and are not mineralized. They were evidently deposited after vulcanism on the island had ceased.

*Glacial Deposits.*—Texada island was probably entirely covered with ice during the Glacial Period, and deposits of this age consisting of boulder clays, stratified sands, silts, clays, and gravels on the lower lands, and scattered erratics on the higher, are present everywhere. The boulder clays and associated beds are not evenly distributed, and occur mostly in irregular areas extending inland from the west coast. Over the greater part of the island the covering is thin, and ridges and hummocks of the older rocks project through it.

## Mines and Minerals.

The principal mineral deposits of Texada are situated in the northern part of the island, and were briefly described in the Summary Report for 1908. In the vicinity of Van Anda, work was steadily prosecuted during the season on the Marble Bay, Cornell, and Little Billy mines; and in addition the Copper Queen was unwatered and some exploratory work done.

The principal work carried out on the Marble Bay mine during the past year consisted in exploring the new ore body first encountered in the 10th level at a depth of 863 feet. It has proved to be an exceedingly important one. At a depth of 960 feet, the present working level, this ore body, shaped like a flattened V with the apex to the west, has a proved length of 180 feet and an average width of about 15 feet. The grade of the ore is somewhat higher than usual, the first-class ores carrying about 11 per cent copper, $10 in gold, and from 5 to 6 ounces of silver per ton. Among the more important changes noted in depth, in this mine, are the increasing proportion of bornite compared to chalcopyrite, the better definition of the ore body, the copper sulphides around the greater part of the periphery ceasing abruptly against a lime wall in place of diminishing gradually through a bordering zone of secondary mnerals, and the introduction between the 10th and 11th levels of native silver in small, thin leaves, scales, and grains. The silver occurs mostly with the bornite, occasionally in the calcite gangue, and never, so far as noted, with the chalcopyrite. The addition of native silver to the ordinary minerals of the ores is marked by an increase in the silver tenor from 3 or 4 ounces to 5 or 6 ounces per ton.

At the Cornell mine the extension of the 360 ft. level has resulted in the discovery of several fair sized ore bodies, all, with one exception, carrying high grade ore. The shipments from these average at present about 1,000 tons per month. Development work is now in progress to ascertain if the ore bodies extend down to the 460 ft. level. No ore has so far been found in this level. The ore bodies of the Cornell, while more numerous, are smaller and more uncertain than those of the Marble Bay mine.

Development work on the Little Billy during the season consisted in running a drift from the old workings to undercut a surface showing in the limestone. An ore body enclosed in limestone was encountered, the full dimensions of which have not yet been determined, although it has been proved to contain a considerable tonnage of good ore.

Some development work was also done on the promising Loyal Lease claims, near Blubber bay, but no ore bodies of value were found. The important iron range on the west coast briefly described in last year's Summary was idle during the season.

South of Raven bay a mining enterprise of some magnitude has been commenced, viz., to drive a tunnel, starting near sea-level on the coast, inland under Comet mountain. The tunnel as projected will have a length of 3,000 feet or more, and—except near the mouth where it skirts a quartz-diorite-porphyrite contact—will pierce porphyrites holding occasional small inclusions of lime all the way. A number of small and medium sized magnetite lenses usually associated with lime inclusions, and some quartz veins, outcrop on Comet mountain and in its vicinity. The development work on these consists of a few open-cuts, and shafts sunk to varying depths, up to 70 feet. The magnetite lenses usually contain chalcopyrite, but no large body of shipping ore has so far been uncovered, and the purpose of the tunnel seems to be largely exploratory.

The southern part of Texada island is not mineralized to the same extent as the northern portion. Most of the important mineral deposits of the island occur in connexion with the limestone of the Marble Bay formation, and this stops, going south, a short distance south of Davies bay. The rocks south of this point consist of porphyrites cut by a few quartz-diorite stocks, mostly distributed along the east coast, and of the schists, tuffs, etc., of the Anderson Bay formation. Small lenses of crystalline limestone occur in the latter, but these, unlike the Marble Bay limestone, which is bordered everywhere by intrusive contacts with various igneous masses, are considered to be contemporaneous with the enclosing beds and form part of a regular series.

A few quartz veins, none of which, if a famous lost mine of fabulous richness supposed to exist in the vicinity of Anderson bay is excepted, are noteworthy for size or richness, constitute the discoveries up to the present. The veins carry, in places, chalcopyrite and more rarely bornite, and some good gold assays are reported. None of the veins have been mined and very little development work has been done on them.

## MORESBY ISLAND.

Moresby island was visited in August. The trip occupied nearly a month, although only seventeen days were spent on the island. As hotels are somewhat scarce, my thanks are due to Mr. Ikeda, Mr. Parsons, and Mr. Morgan for accommodation and other courtesies, and to Mr. Sandilands, Mining Recorder, Mr. Nestelle, and others for information and assistance.

### General Description.

The Queen Charlotte islands, of which Moresby island forms the central member, are situated in the Pacific ocean, about 450 miles northwest of Vancouver. They are separated from the islands fringing the mainland by Hecate strait, an open body of

water about 100 miles in width. A regular steamship service with Vancouver is now maintained, and one with Prince Rupert, which is situated almost directly east of the north end of Graham island, will shortly be established.

The principal resources of the Queen Charlotte islands consist of extensive fisheries, a luxuriant forest covering most of the islands, important coal seams on Graham island, and a large mineralized area on Moresby and adjacent islands, the possibilities of which are not yet fully known. Moresby and the southern islands are not well adapted for agriculture on a large scale on account of their mountainous character and excessively humid climate. Graham island, the largest of the group, is much flatter and drier, especially toward the eastern coast, and possesses large tracts capable of settlement.

The Queen Charlotte islands have been neglected in the past, and the development of their varied resources has been slow and spasmodic. Attention has been drawn to them recently, owing to their proximity to Prince Rupert, the projected terminus of a great transcontinental road, and more rapid development is now expected. With the completion of the Grand Trunk Pacific the islands will be within easy reach of an important centre.

Moresby island, a portion of which was hastily examined during the past season, has a length of 110 miles and a width in the northern part of about 25 miles. Southward, the average width decreases to about 5 miles. The coast line on the east is extremely irregular, and is interrupted by numerous bays and branching inlets, some of which cut nearly across the island. The east coast is also fringed by a multitude of islands, ranging in size from mere dots up to areas 8 or 10 miles across. The west coast has never been properly surveyed. It is more regular than the east coast, is free from islands for long distances, and harbourage is obtainable only at a few points.

The interior of Moresby island, from the southern end, north to Tasoo harbour, the portion visited, is hilly and mountainous throughout. At the southern end the mountains rise steeply from the water's edge to an elevation of from 1,000 to 2,000 feet and are wooded to their summits. Northward they increase in height, and, in the vicinity of Tasoo harbour and for some distance north and south, the main range is formed of a sierra of high, rugged peaks, rising far above the timber line.

The island is forested, densely in the valleys and more sparingly on the higher mountain slopes, up to an elevation of about 2,000 feet, the timber line of the district. The Douglas fir, the principal coast tree of southern British Columbia, is absent, and its place is taken by the gigantic Sitka spruce (*Abies sitchensis*), which furnishes excellent timber. Several specimens of this tree were seen which exceeded 10 feet in diameter. Other prominent forest trees are the red cedar (*Thuya plicata*), the valuable yellow cedar (*Chamœcyparis Nookatensis*), and a hemlock (*Tsuga heterophylla*). Shrubs grow densely and render travelling, except along the timber line, exceedingly slow and laborious.

The decay of the luxuriant vegetation has produced a heavy muck covering which is kept soft by the constant rains. The muck covering, encumbered as it usually is with numerous large fallen trees, makes trail building for men difficult and trail building for horses impossible except at great expense, and at present all supplies for the interior camps are packed up on men's backs.

## GEOLOGY.

A geological examination of Moresby and the other Queen Charlotte islands was made by Dr. Dawson in 1878, and his report, published by the Geological Survey in 1880, is still the principal authority on their geology.

### Sedimentary Rocks.

The older formations are not represented on the portion of Moresby island visited. and the principal sedimentary rocks seen consist of whitish and dark shales and feldspathic sandstones, probably of tufaceous origin, filled in places with Triassic fossils. The tufaceous beds are thinly bedded as a rule, and often pass into and alternate with thin beds and bands of greyish limestone. They are usually disturbed and faulted and are cut in all directions by numerous dikes.

Massive greyish limestones, usually more or less crystalline, are widely distributed in small areas, mostly as inclusions in the later intrusive rocks. They were not seen wth the tufaceous beds, and their relative age is not definitely known. Fragments of limestone, ranging in size from a few feet to half a mile or more across, occur along the east coast from Carpenter bay, north to Lockeport, and were also seen at Tasoo harbour on the west coast. They are of considerable economic importance, as many of the ore bodies of the island have formed in or near them.

### Intrusive Rocks.

*Porphyrites.*—The most widely distributed rocks in the district visited consist of medium grained, dark basic intrusives made up mostly of hornblende and a plagioclase feldspar. They are usually more or less porphyritic in texture, and are classed generally as hornblende porphyrites. The more granular varieties resemble diorites in hand specimens.

The rocks of this group occur on Collison bay, on Ikeda bay, at Jedway, and at points between Jedway and Lockeport, and on Tasoo harbour. They are massive and comparatively fresh as a rule, but in places are strongly fissured. Numerous magnetite lenses have formed in them, often near small inclusions of lime.

*Diabase.*—Rocks often showing a strongly marked ophitic structure, even in hand specimens, are distributed over a considerable area in the vicinity of Klunkwoi bay and Anna lake. Their relationship to the preceding group was not ascertained. They are mostly dark greyish, medium grained massive rocks, slightly porphyritic in places and occasionally amygdular. They are interesting economically, as considerable areas are sparingly impregnated with copper sulphides.

*Granites.*—Greyish granitic rocks, mostly granites, but probably including several types, outcrop on the Collison Bay-Huston Inlet summit and vicinity, on Apex mountain, and on portions of Tasoo harbour. They are younger than the dark intrusives, and probably represent the period of the Coast Range batholith.

*Dikes.*—Dark greyish dikes, mostly hornblende porphyrites, but occasionally augite porphyrites, are numerous in the vicinity of Collison bay, Ikeda bay, Jedway, and other places. They cut all the formations, both sedimentary and igneous, previously described, and are also found traversing the ore bodies. They are younger, in some instances at least, than the mineralization of the district.

## DESCRIPTION OF MINES AND PROSPECTS.

### Collison Bay.

*Collison Bay Mining Company.*—The principal work in the vicinity of Collison bay is being done at present by the Collison Bay Mining Company, Walter H. Parsons, manager. The Company owns the Kenora claim and the Office fraction, and are working the Black Prince under bond. The claims are situated about half a mile from the beach at an elevation of about 500 feet above it.

The country rock is a massive hornblende porphyrite. It holds some small limestone inclusions and is cut by numerous dikes.

The surface showings consist of seven vein-like leads, evidently following fissures or zones of fissuring. Five of these run nearly north and south and are approximately parallel, while two have a NW-SE strike. The main lead has been stripped for 150 feet and uncovered at intervals for 800 feet. Its width varies from 1 to about 5 feet, but it swells out to 12 feet at a point known as the Gordon Cut. The vein filling is mostly magnetite, but varies greatly along the strike. At the Gordon Cut it consists of chalcopyrite and pyrrhotite in a gangue of altered country rock. The sulphides are accompanied by small quantities of garnet, dark amphibole, augite, and calcite. South of the Gordon Cut, the main lead splits up into three branches, all somewhat similar in character, except that the most westerly one follows for some distance a limestone inclusion from 1 to 2 feet wide. Chalcopyrite occurs somewhat plentifully in the lead where it follows the lime, while beyond it in both directions the vein consists mostly of magnetite.

The main lead near the Gordon Cut outcrops on a steep hillside, and is opened up by a cross-cut tunnel which reaches the vein at a distance of 110 feet. From the end of the cross-cut, a tunnel has been run southward along the lead for 28 feet and northward 184 feet to a point under the Gordon Cut. An incline shaft 97 feet in length has also been sunk at the end of the south drift, and some drifting done at its foot. The development work has been planned judiciously, but the results so far have been disappointing. The ore continues down, but at the depth reached is less concentrated than on the surface and the values are stated to be lower.

At the time of my visit work on the main lead was suspended and one of the cross leads was being opened up. This lead is traceable for about 200 feet, and at one point swells out to a width of 20 feet. A cross-cut tunnel is now being driven towards it. The vein filling on the surface is principally magnetite holding considerable chalcopyrite, and is said to carry good values in gold.

*Oceanic.*—This claim is situated close to the beach at the head of Collison bay. The country rock here is a porphyrite holding some small limestone inclusions. There is no defined lead, and the ore consists of the altered and mineralized limestone and portions of the bordering intrusive. The valuable minerals present are chalcopyrite and small quantities of bornite. The deposit has been opened up by two shallow pits 30 feet apart, and some surface stripping. Twelve tons of ore, said to have yielded 3 per cent copper and small values in gold, have been shipped.

*Meal Ticket.*—The showing on the Meal Ticket is situated near the foot of the ridge bordering Collison bay on the northwest, at an elevation of 225 feet above sea-level, and consists of a tabular lens of magnetite apparently lying in a nearly horizontal position in porphyrites. The lens has a thickness of from 3 to 8 feet and is exposed on the hillside for a distance of about 200 feet. The principal minerals associated with the magnetite are chalcopyrite, pyrrhotite, epidote, garnet, and quartz. The chalcopyrite is somewhat sparingly distributed through the magnetite, except along a stretch about 30 feet in length near the north end, where it is fairly abundant. A small, vein-like lead south of the magnetite lens contains some good ore, principally chalcopyrite.

The development work consists of two tunnels, one 35 feet in length situated immediately below the south end of the ore body, and the other 80 feet in length lower down the slope. Neither of the tunnels affords much information.

*Princess Group.*—This group is situated at an elevation of 1,500 feet above sea-level on the crest of a ridge overlooking Carpenter bay. The rocks consist of a wide granite dike, cutting basic igneous rocks, too altered for recognition, and occasional outcrops of crystalline limestone. A lens of magnetite about 45 feet in length and 18 feet in width, holding considerable chalcopyrite at one point, outcrops a short distance below the summit of the ridge at the contact of the two intrusives. A strong lead

showing decomposed magnetite in places also crosses the summit, and is exposed by small open-cuts. The principal development work consists of a tunnel driven through the magnetite lens and for some distance into the country rock beyond.

*Iscroyd Group.*—These claims are situated about 3 miles from Collison bay across the summit to Huston inlet, at an elevation of 600 feet above sea-level. The rocks here are whitish altered tuffs cut by a granite stock. Both rocks are mineralized along their contact over a considerable area with chalcopyrite and pyrrhotite. The open-cuts which constitute the present development work show two small areas, holding considerable chalcopyrite, both of which occur in altered granite. In the tuffs, pyrrhotite is the principal mineral.

## Ikeda Bay.

Ikeda bay is situated a short distance northwest of Collison bay, and is connected with it by a foot trail. Most of the claims in the vicinity are owned by Awaya, Ikeda & Co., a Japanese company. This Company controls 47 claims and, under the management of Mr. Ikeda, has done a large amount of work, principally on the Lily group.

### LILY MINE.

The country rock in the vicinity of the Lily mine and Ikeda bay is a dark, massive, medium grained hornblende porphyrite, resembling a diorite in hand specimens. It is fissured in places, holds occasional inclusions of lime, one of which crosses the Lily lead, and is cut by a number of porphyrite dikes which are later than the mineralization. It is probably an extension of the intrusive area exposed at Collison bay, but is less distinctly porphyritic.

*Development.*—The Lily mine is situated about a mile from the beach. The lead outcrops on a slope rising at an angle of 20°. The main workings consist of a tunnel 800 feet in length and two short tunnels higher up the slope, all following a long, fissured zone. A fourth tunnel at an elevation of 300 feet above the main one and starting 250 feet beyond it, has also been commenced. It follows a shear zone, considered by the management to be a continuation of the one followed in the lower levels. In the upper level a small lime fragment is enclosed in the diorite.

*Ore Bodies and Ores.*—In the lower level two ore bodies were encountered, the first 25 feet and the second 175 feet in length. The latter has been stoped to the surface. Its width varies from 2 to 10 feet and averages about 4 feet. The ores consist of chalcopyrite, carrying some values in gold and silver, associated with pyrrhotite, pyrite, and rarely, magnetite. The gangue is principally the more or less altered country rock usually holding small quantities of various secondary minerals, principally epidote, garnet, hornblende, calcite, and quartz. Shipments of 2,342 tons of ore have been made from this vein, averaging about 10·4 per cent of copper, 4 ounces silver and 0·238 of an ounce gold per ton. No ore has been taken out so far and no development work done below the level of the tunnel.

The shear zone striking nearly south and dipping steeply to the east has been explored for some distance beyond the ore body. The fissured porphyrite is altered and mineralized in places, but no shipping ore was found.

A drift to the west from the lower tunnel about 550 feet from its mouth led to an important discovery. The drift followed a branch fissure carrying some scattered ore, and at a distance of about 100 feet entered a large ore body, the full extent of which is not yet determined. The present chamber has a length of over 70 feet and a width of 51 feet. The porphyrite here is cut by two dikes and is fissured in various directions, but not shattered. The ore is low grade, and consists of grains, bunches, and small lenticles of chalcopyrite and pyrrhotite scattered through the country rock.

Small quantities of pyrite and magnetite are also present. The porphyrite is somewhat altered, and various secondary minerals, including quartz, calcite, epidote, garnet, and hornblende are sparingly distributed through it. The shipments yielded 2·99 per cent copper, 1·21 ounces silver and 0·076 of an ounce gold per ton. Shipments up to the present aggregate about 6,000 tons.

*Equipment.*—The equipment at the mine includes an 80 horse-power boiler, an Ingersoll-Rand compressor running three drills, and a donkey engine used for hauling up the empty cars. A wharf with capacious ore bunkers has been built on Ikeda bay, and is connected with the mine by a tramway 6,200 feet in length. The buildings include an excellent boiler house, machine and blacksmith shops, and several cottages.

With the exception of the Lily group, the numerous claims of the Awaya-Ikeda Company are still practically undeveloped. Some stripping and surface work has been done on the Crysanthemum group, and several magnetite lenses, one about 100 feet in length, have been exposed. The magnetite, as usual, carries some copper and iron sulphides. On the Wistaria claim a small calcite vein carrying free gold has been explored for a short distance. Numerous exposures of mineral, mostly magnetite, are reported on other claims, but were not examined.

## Jedway.

Mining at Jedway, on Harriet harbour, was at a standstill at the time of my visit, principally on account of litigation over various properties. Numerous discoveries have been made in the neighbourhood, but with the exception of a tunnel on the Copper Queen, little development work has been done.

*Geology.*—The rocks seen include tuffs, argillites, and interbedded limestones of Triassic age. These are well exposed along the coast, but are replaced, going inland, by a dark slightly porphyritic rock similar to that at Ikeda bay. The latter is intruded at various points by greyish granite. Massive limestones also occur on Copper island, and at various other points, as inclusions in the porphyrite and granite.

*Copper Queen.*—This claim is situated on the southwest side of Harriet harbour at an elevation of 750 feet above sea-level. A tram-line to the beach, 4,800 feet in length, has been cut out. The mineral exposures consist of a number of magnetite lenses outcropping along a creek over an area about 200 feet long by 50 or 60 feet in width. The rocks here consist of hornblende porphyrite cut by granite, and most of the lenses have formed along the contact or in the granite near it. A small lime inclusion occurs at one point in the granite. The lenses so far explored are small, but carry considerable chalcopyrite in places and have yielded some good ore. A tunnel, designed to cut the line of lenses at a depth of 110 feet, has been driven into the hillside for a distance of 370 feet. The tunnel pierces granite for 300 feet, then a zone of altered rock holding some iron, and terminates in porphyrite. No large body of ore was encountered. The absence of ore along the line of the tunnel does not conclusively prove that the lenses are confined to the surface, and a drift from the tunnel along the granite-porphyrite contact will be necessary to test this point.

*Moresby Island.*—The Moresby Island mineral claim is situated some distance south of the Copper Queen at an elevation of 750 feet above sea-level. A porphyrite-lime contact crosses the claim, and both rocks for some distance back from the contact are altered, and mineralized with the usual contact metamorphic varieties. Garnet is present in considerable quantities, and also epidote and calcite. The metallic minerals include chalcopyrite, pyrite, zinc blende, and a little magnetite. The development work on the claim is limited to a few small open-cuts and some stripping, insufficient to determine either the extent of the mineralized area or the quality of the ores.

*Iron Mountain or Magnet.*—This claim is situated about a mile from Harriet harbour, on the divide between it and Huston inlet, at an elevation of about 1,300 feet above sea-level. It contains a large magnetite body about 400 feet in length, with a width at one point of fully 100 feet. The magnetite is enclosed in porphyrite, except at the north end, where some crystalline limestone is exposed. It is unusually free from impurities, on the surface at least, but contains some garnet, epidote, calcite, and cores of more or less altered country rock. Iron and copper sulphides in small quantities and some blende are also irregularly distributed through portions of the mass. The magnetite is reported to assay from $2 to $3 in gold. It has remarkable magnetic qualities and acts as a natural lodestone. The development work consists of some stripping, a surface cross-cut to determine the width of the ore body, and a short tunnel along the foot-wall.

*Dingo.*—The ore outcrops on the Dingo claim consist of a magnetite lens 10 to 15 feet in width. The lens is exposed by surface cuts at two points about 60 feet apart, and is said to be traceable for a considerable distance. The surface exposures contain little or no copper.

Magnetite lenses also occur on the Reco, Modoc, and other claims in the vicinity.

## Copper Island.

Copper island is situated in Skincuttle inlet, about 4 miles north of Jedway. The island is about half a mile in diameter, and several claims have been staked on it, now mostly owned by A. Heino. A wide band of massive greyish crystalline limestone crosses the island, and is bordered by a dark medium grained basic intrusive resembling a diorite but classed with the hornblende porphyrites. The mineral occurrences consist of a number of small quartz and calcite veins, occasionally carrying a little copper, traversing the porphyrite, and an irregular but extensive contact metamorphic zone along the lime-porphyrite contacts, both rocks as usual being affected. Garnets have developed in large quantities, and are accompanied by smaller amounts of epidote, hornblende, calcite, and quartz. The metallic minerals present include the two copper sulphides chalcopyrite and bornite, pyrite, and some scattered magnetite. In addition to these a small veinlet of tennantite, and some cuprite, both probably derived from the sulphides, occur at one point.

The contact metamorphic zone on Copper island is the most typical one seen in the district, and the geological conditions are very similar to those in the vicinity of the rich copper deposits of Texada island. The exploratory work consists of a short tunnel and some shallow pits and shafts. A few tons of picked ore have been shipped, but no large ore body of commercial value has so far been found.

A large number of claims have been staked on Huston inlet and Burnaby island, but as little development work was in progress on them, they were not examined.

## Klunkwoi Bay and Vicinity.

From Jedway northwest along the coast to Lockeport, a distance of about 40 miles, while claims have been staked at various points, little mining is being done.

In the vicinity of Lockeport, also, although practically the whole country has been staked, few of the claim holders are doing more than the necessary assessment work.

*Swede Groups.*—The principal claims near Lockeport, or at least those on which the most work has been done, are known as the Swede group. They are situated on a steep-sided, wooded ridge about half a mile wide and 1,000 feet high, bordered on both sides by inlets from Klunkwoi bay. The group is formed of eight claims extending across the ridge.

The country rock is a dark, medium to rather coarse grained diabase, often amygdaloidal in character. The cavities in the amygaloidal variety vary in size up to about half an inch in diameter and are filled principally with yellowish green epidote, usually accompanied by subordinate quantities of quartz and calcite, and more rarely, chalcopyrite and pyrite. The diabase is quite massive, showing in hand specimens no sign of crushing. It is crossed by a few strong fissures, but is not conspicuously fractured or jointed. Epidote has developed abundantly in certain areas, partially replacing the original constituents, but as a rule the alteration is not excessive. Occasional limestone inclusions, none seen being conspicuously mineralized, occur in the diabase, and it is also crossed by a few dark basic dikes.

The ore consists simply of the diabase, usually more or less epidotized, sparingly impregnated with chalcopyrite and occasionally a little bornite. The chalcopyrite occurs in grains, small aggregates, and tiny veinlets scattered through the close textured, more or less altered diabase and also in the filling of the amygdules in the vesicular variety. It is irregular in its distribution, and seems to occur in patches often of considerable extent, alternating with barren areas.

The development work on the Swede group consists of several long open-cuts, all showing mineral situated at intervals up the steep mountain side to a height of 700 feet, and two tunnels near sea-level, over 100 feet long. The tunnels were driven by I. Wolffsohn, of Vancouver, who now holds the property under bond. Ore in wide irregular patches occurs along both tunnels, but except in spots appears to be low grade. A general sample from a 75 ft. face in one of the open-cuts, collected by Mr. Fleet Robertson, Provincial Mineralogist for British Columbia, is stated by him to have yielded a little over 2 per cent copper with traces of gold and silver.[1] This probably nearly represents the average copper tenor of the diabase in the larger mineralized areas, judging from the present limited exploratory work.

The outline of the copper-bearing diabase has not been defined, but it is known to outcrop over an area of several square miles, and numerous locations have been made on it at widely separated points. It is quite possible and even probable that with further prospecting higher grade ore in quantity will be found.

The genesis of these peculiar deposits is not fully understood. The intimate intermingling of the sulphide grains with the other rock-forming minerals in some specimens gives the impression that the chalcopyrite formed one of the original constituents. On the other hand, the occurrence of the chalcopyrite in the amygdules and in small veinlets as well as in grains, and the occasional highly altered and epidotized condition of the diabase in its vicinity render this view unlikely; and it is more probable that they are of pneumatolytic origin and that the sulphides were deposited from gaseous emanations possibly emitted from the still liquid lower portion of the diabase magma after the upper part had cooled. The strong fissures occasionally seen cutting the diabase and the dikes which intrude it have had no apparent effect on the mineralization, and both are probably younger.

*Nelson Group.*—These claims are situated near Lake Anna, on the trail from Klunkwoi bay to Tasoo harbour. The country rock in the exposures seen at the lake shore is a dark basic intrusive resembling that at the Swede group, and the mineralization, consisting of an impregnation of the altered country rock with chalcopyrite, is also very similar. The development work has only begun, and the extent of the mineralized area is not yet known.

Magnetite lenses are reported in the mountains south of the lake, but were not visited.

*Apex Claims.*—The Apex claim is situated about a mile southwest of Lake Anna, near the crest of the high mountainous ridge which forms the watershed of the island.

[1] Report of the Minister of Mines, B.C., 1907, p. 70.

The ridge has a general elevation here of about 2,700 feet, and is surrounded by occasional peaks rising 200 or 300 feet above it.

The rocks at the claim consist of a lime wedge, about 100 yards wide on the surface, enclosed in a greyish granitic rock, both cut by porphyrite dikes.

A short distance below the sharp crest of the ridge a large magnetite lens outcrops on the south slope, and apparently extends through the ridge, here about 400 feet across; as a similar magnetite is exposeed at about the same elevation on the north slope. The lens on the south slope has a maximum width of 50 feet and is traceable up the mountain side for a distance of about 100 feet. On the north slope the maximum width is 125 feet and the height about 60 feet.

The magnetite formed in and replaced a portion of the limestone, near its contact with the granite. It includes a number of limestone cores and also small areas made up mostly of garnet and calcspar. It is stained nearly everywhere on the surface with copper carbonates, and in places chalcopyrite is fairly abundant. The copper tenor, judging from the surface exposures, seems important, but the percentage is not known as practically no work has been done on the claim.

A second large magnetite mass outcrops on a ridge about half a mile west from the Apex lode. Only small quantities of copper are visible in the surface exposures.

*Copper Belle.*—This claim is situated in a high basin north of Apex mountain. The claim is crossed by a strong porphyritic dike. The showing consists of a magnetite lens about 20 feet in width bordering the dike. The magnetite carries considerable chalcopyrite in places.

*Albia Claim.*—The Albia is situated in the Apex basin northeast of the Copper Belle. The country rock is an altered greenstone, probably a porphyrite cut by a porphyrite dike. Near the dike the country rock is crushed on the hanging-wall side for a distance of 10 to 15 feet and impregnated with pyrites. Gold values of $10 per ton are reported to have been obtained from a zone 4′–8″ in width bordering the dike.

## Tasoo Harbour.

Tasoo harbour is on the west coast opposite Lockeport, and is reached from the latter point by a trail 3½ miles in length. The trail starts from an inlet of Klunkwoi bay, south of Lockeport, climbs 500 feet to Lake Anna and a further 1,300 feet to the summit of the dividing ridge. The descent to the west coast is rapid, the flats bordering it being reached in less than a mile from the summit.

A second trail from the head of Crescent bay has been built by the Provincial government. The summit crossed by this trail is reported to be very low, only 200 or 300 feet in height.

Tasoo harbour is probably the best of the few harbours on the west coast, but is difficult to enter except at slack tide, owing to the rapid current produced by the water forcing its way through the narrow outlet. It is a large irregular body of water over 15 miles in length, consisting of a wide central portion and three deep bays known as the North and South arms and Botany bay. It has never been surveyed, but is said to have over 100 miles of shore-line. It is surrounded on all sides by high ridges and mountains wooded up to a height of 2,000 feet and bare above, which rise from the water at angles often exceeding 50°.

*Geology.*—Only a portion of the harbour was examined. The rocks seen consist mostly of intrusives similar to those on the east coast. A medium grained greyish granitoid rock classed as a granite outcrops around the head of Botany bay, and is also found on the South arm. It intrudes a dark basic rock referred to the hornblende porphyrite group. Both intrusives are cut by numerous porphyrite dikes, and also hold occasional inclusions of limestone.

*Contact Group.*—This group includes a number of claims staked on a ridge south of the head of Botany bay. The present workings are situated on the summit of the ridge, at a height of 2,400 feet above sea-level. The country rock here is an altered greenstone, much fractured, and crushed almost into a schist in places. It is cut by a number of dikes, mostly porphyrites, but including a few which are apparently apophyses from a large granite area crossed ascending the ridge.

The showings consist of a number of irregularly distributed magnetite lenses enclosed in greenstone. The magnetite is oxidized on the surface and the red outcrops are very conspicuous, but the present open-cut workings have not so far disclosed any large body carrying copper in commercial quantities. The principal minerals associated with the magnetite are chalcopyrite, pyrite, pyrrhotite, epidote, and garnet.

A large magnetite lens is stated to outcrop some distance below the present workings, on the crest of the ridge, but was not seen.

*Warwick Group.*—These claims are situated south of the entrance to the South arm of Tasoo harbour, and are distant about 8 miles from the end of the Lockeport trail at the head of Botany bay. The principal workings are at an elevation of 1,160 feet above sea-level, and 2,000 feet from it in a direct line.

The country rock is a dark, medium-grained hornblende porphyrite, holding a large inclusion of crystalline limestone. The mineral showings occur partly in the limestone and partly in the porphyrite, and consist of magnetite in unusually large masses, associated with chalcopyrite, pyrite, and pyrrhotite.

Development work was commenced on these claims in June of the present year, and has been pushed energetically. Besides considerable surface work, consisting of trenching, stripping, and open-cuts to define the ore bodies, a tunnel 100 feet in length has been driven into the main magnetite mass. The tunnel section consists mainly of magnetite, alternating at one point with a band of limestone 15 feet in width and cut by some dikes. Magnetite interbanded with limestone is also shown by surface exposures to extend 100 feet beyond the end of the tunnel. The full length of the ore body is not yet known.

The magnetite is associated with chalcopyrite in grains and bunches, pyrite, and pyrrhotite. The non-metallic secondary minerals usually accompanying similar deposits are not conspicuous. The copper sulphides occur somewhat plentifully in the magnetite near the two ends of the tunnel, and in smaller quantities along the central portion. A considerable proportion of the material extracted is considered by the management to be of shipping grade, but the average copper tenor was not ascertained.

A second magnetite mass, which has apparently developed in porphyrite, as no limestone was seen, occurs 800 feet northwest of the one tunnelled. It has not been fully defined, but is of large size—fully 100 feet in width and 200 feet in length, at least. Magnetite outcrops, probably marking a line of lenses, are also stated to extend down to the beach.

## GENERAL SUMMARY.

### Principal Metallic Minerals.

*Magnetite.*—This is much the most abundant mineral seen. It occurs in irregular-shaped areas, varying in size from small bunches to great masses 300 to 400 feet or more in length, in long vein-like forms, and in grains disseminated through the altered rocks. It is usually associated with iron and copper sulphides, garnet, epidote, and other contact metamorphic minerals.

*Pyrrhotite.*—Pyrrhotite is common in most of the magnetite lenses and in the altered areas. No high gold values have so far been found in it.

*Pyrite.*—Pyrite occurs with the magnetite, but is less abundant than pyrrhotite. A pyritic zone on the Albia is said to carry fair gold values.

*Chalcopyrite.*—This is the principal valuable mineral worked at present. It occurs in grains and bunches in practically all the magnetite lenses; in altered contact zones; in shear zones, as at the Lily, associated with the iron sulphides; and impregnating in small quantities considerable areas of altered diabase. Its distribution in the magnetite lenses is erratic, and the proportion present is also very variable.

*Bornite.*—Bornite occurs in small quantities associated with chalcopyrite on the Oceanic, on Copper island, and in the copper-bearing diabase of Klunkwoi bay.

*Tennantite.*—A small vein of tennantite occurs in the altered contact rocks of Copper island.

*Cuprite.*—Cuprite is found in small quantities on Copper island.

*Sphalerite.*—Sphalerite occurs sparingly in some of the magnetite lenses, and in the altered contact zone.

*Gold and Silver.*—A small calcite vein carrying free gold occurs at Ikeda bay, and most of the sulphides carry small values in gold and silver.

*Gangue Minerals.*—The gangue minerals consist of the usual contact metamorphic varieties. Garnet and epidote, the most abundant of these, are present in some quantity in nearly all the mineral occurrences seen. They occur as individuals and in small aggregates both in the ore and adjoining country rock, but have seldom developed in sufficient quantities to form large pure masses as in the Whitehorse district. Other gangue minerals commonly present are calcite, quartz, hornblende, augite, and chlorite.

## Character of Deposits.

With the exception of a few small quartz and calcite veins of questionable value, practically all the mineral occurrences seen are replacement deposits, most of them situated at or near lime-porphyrite or granite-porphyrite contacts. A few occur in the interior of the intrusive masses, some of which follow evident shear zones, while others are indistinguishable in appearance and contents from the ordinary contact lodes.

The majority of the ore bodies consist of irregular-shaped masses of magnetite, most of them small; but a few measure from 100 to 400 feet in length and 100 feet or more in width.

The magnetite lenses always carry iron and copper sulphides in some quantity, and occasionally chalcopyrite is developed, in portions of the mass, in sufficient quantities to constitute shipping ores. The gold and silver values found so far are small.

The typical irregular-shaped magnetite lenses grade into long vein-like forms. These, in some instances, have magnetite as the principal vein filling, and in others chalcopyrite and the iron sulphides are the chief minerals present.

The gangue, in both the magnetite and sulphide ore bodies, consists of the country rock in which they developed, usually more or less altered and partially or wholly replaced by secondary minerals.

The peculiar low grade copper deposits in the Klunkwoi diabase are described on a previous page, in connexion with the Swede group. In them, chalcopyrite, sparingly distributed through the diabase, and epidote, are the principal minerals present.

## Present Status of Mining.

While iron and copper minerals have been known to exist in the Queen Charlotte islands for several decades, the present activity in mining practically commenced in 1906. Since then prospecting has been vigorously prosecuted, and has resulted in the

discovery of several extensive mineralized areas in which nearly 1,300 claims have been already staked. A large percentage of the discoveries consists of small and medium sized magnetite lenses of doubtful value.

While prospecting has been active, development work has proceeded slowly, and few of the numerous discoveries have been tested even superficially.

The Lily mine, the only one on the island on which any considerable amount of work has been done, has been proven to contain two important ore bodies, one high grade and the other low, and shipments totalling over 8,000 tons have been made from them. Small shipments have also been made from the Oceanic and from Copper island.

During the season development work was in progress on the claims owned by the Collison Bay Mining Company on Collison bay, and on the Contact and Warwick groups in Tasoo harbour. A small amount of work, principally necessary assessment work, was also done on a number of other claims.

The deposits of the so-called contact-metamorphic group are characteristically bunchy and uncertain both in permanence and tenor of valuable minerals, and only occasionally, as experience on the coast has shown, have the tonnage and values necessary to make important mines. The development work on Moresby island, small as it is, has led to several disappointments, but has also proved the presence of ore of shipping grade at a number of widely separated points, although only rarely in quantity. The results obtained so far, measured by the amount of work done, are not unfavourable, and warrant more energetic development work than is being done at present.

# SOUTHERN VANCOUVER ISLAND.

*(Charles H. Clapp.)*

## INTRODUCTION.

### General Statement.

The work carried on by the writer during the past field season, from June 22 to September 17, in the southern part of Vancouver island, was entirely of a reconnaissance nature, although detailed work was done by his assistant, John A. Allan, assisted by F. J. Barlow, on the east coast. During the last month, Mr. Allan extended the reconnaissance farther to the north. The other assistants were: James Caffery, Charles E. Blogg, and Frank Caffery.

The coast line from Point Nopoint to Bamfield creek and the shores of Nitinat lake were first examined. A traverse was made up Jordan river, across the divide and down San Juan river to its mouth. Another traverse was made up Gordon river, with a side trip up Bugaboo creek, across the divide and down Sutton Creek valley to Cowichan lake. Three weeks were spent at Cowichan lake and immediate neighbourhood. The low divide at the west end of the lake was then crossed, and the coast reached by way of Nitinat river and lake. The rest of the season was spent examining the eastern and southern shores of Barkley sound and Alberni canal. Mr. Allan spent the last month in the field on a reconnaissance across the island between Mount Brenton and Alberni.

### Location and Area.

The geological reconnaissance was confined to the southern part of Vancouver island. In the past and preceding seasons, the area to the south of the Alberni-Nanaimo road and to the east of Alberni canal and Barkley sound, has been explored, covering, in all, roughly 4,000 square miles. The examination was necessarily confined to the more accessible parts, and no work was done on the east coast north of Ladysmith.

### Previous Work.

In the area explored, little previous work had been done, for Selwyn, Richardson, and Dawson, of the Geological Survey, confined their attention to the extreme southeastern part and to the coal-bearing rocks of the east coast. Later, Dawson examined the northern part of the island. In 1902, Webster and Haycock, on behalf of the Geological Survey, made a cursory examination of the west coast of the island. The writer's own work of 1908 did not extend into the area examined during the past season. Considerable work of a less general nature has been done by the Provincial Department of Mines, in special, scattered localities. Mr. E. Lindeman examined the iron ores of Vancouver island for the Mines Branch in 1907, and reported upon the iron deposits of Gordon river in the Summary Report of the Mines Branch for 1907-1908.

### Summary and Conclusions.

The rocks of the southern part of Vancouver island are largely crystalline. Two main formations occur: the Victoria group and the Vancouver group. The Victoria group is the older, and is provisionally assigned to the Palæozoic. It forms a broad belt underlying the southern part of the area, and consists of slates and schists, metamorphosed basic volcanics, and marbles.

The Vancouver group is lower Mesozoic in age. It consists chiefly of volcanic rocks, largely basic types, but dacites and quartz porphyries occur. The basic members have been altered to greenstones and schists. Some of the volcanic rocks, probably of the upper part of the series, are interbedded with slates and shales.

The above formations have been subjected to mountain building forces and invaded by stocks and batholiths. The plutonic rocks have a wide range of composition, but the chief rock type is granodiorite; they are correlated with the Coast Range batholith of the main coast, which probably is upper Jurassic in age.

During the Cretaceous, the sedimentary rocks forming the Cowichan group were deposited unconformably upon all of the above crystalline and metamorphosed rocks. It is probable that sedimentation was not continuous throughout the Cretaceous, but that the group consists of two or more distinct formations.

In late Cretaceous or early Tertiary time, the Cowichan group was folded, and it has suffered from the same erosion that planed off the underlying crystalline rocks. The detritus of this Tertiary erosion was in part deposited in marine basins along the southern and western shore of the island.

In the Glacial Period, the island was covered by an ice cap. Glaciers occupied the principal valleys and widened and deepened them. On the retreat of the ice, the morainal deposits were variously modified, and the present thick mantle of drift is of slide, fluviatile, lacustrine, and marine origin.

With the exception of the coal deposits of the east coast, the mineral resources of the area have been but little developed. These resources, although possibly not extensive, are varied and of prospective interest. Gold occurs in the gravels of the streams draining the area underlain by the Leech River slates, and has been derived from very low grade, quartz veins in that formation. The gravels are usually quite rich, but are not very abundant. Large accumulations of gravel at the old mouth of Lost river and near the mouth of the present Sombrio river, are being exploited at present.

Copper prospects are numerous, and some ore has been shipped from the Gladys mine on the Alberni canal. The deposits are chiefly developed in the contact-metamorphosed limestones of the Victoria and Vancouver groups, and are, as a rule, small, irregular, and of low grade. Some of them are, however, of considerable economic interest. Other copper deposits occurring as disseminations in shear zones and as veins in sheared rocks, are of little importance.

Large bodies of magnetite occur along the contact of the Nitinat limestones and diorite. The bodies are large, and low in phosphorus; but high in sulphur. The chief deposits occur in the valleys of Gordon river and Bugaboo creek.

The limestones of the area furnish ample material for flux, and for the manufacture of lime and cement. Low grade clays occur in the stratified Pleistocene and recent deposits. Good building stones are not abundant; but some of the granites, marbles, and sandstones are possibly suitable for this use.

Coal is apparently absent from the areas of Cretaceous rocks other than the measures of the east coast, and it is almost certainly absent from the Tertiary sediments of the west coast.

## GENERAL CHARACTER OF THE DISTRICT.

### Topography.

The whole of Vancouver island is mountainous save for a relatively narrow strip of lowland along the east coast. With the exception of a few isolated peaks and a more or less broken chain of mountains in the central part, the elevations are characteristically flat-topped or ridge-like. This type of topography is the rule in the southern part of the island, where the mountains and ridges rise rapidly from the shore to a height of about 2,000 feet, and continue to rise inland to heights of 4,500 to 5,000 feet north of Cowichan lake, with, however, a few mountains rising a few hundred feet above the general level of the ridges.

North and west of Cowichan lake a more or less continuous mountain chain extends to and culminates in Mount Arrowsmith: a mountain with several rocky peaks, the highest of which is nearly 6,000 feet above sea-level. The mountain chain extends southeastward from Mount Arrowsmith to Mount Moriarty, and then forks: one chain extending to Mount Benson, west of Nanaimo, and another to Mount Brenton and farther eastward, where it forms the low Mount Sicker range. This more mountainous country, with rock peaks and small perpetual snow fields, is from 10 to 15 miles wide. The greater number of the peaks are under 5,000 feet above sea-level, but all are rock peaks and have been carved by local glaciers. They are, therefore, in great contrast to the flat-topped ridges and cone-shaped mountains, usually covered by timber, which occur to the south and east.

From the nature of the mountains as a whole, it appears that they have been formed by the dissection of an uplifted, old erosion surface. The old surface or peneplain was probably developed in early Tertiary times and unlifted during the Pliocene. Into this peneplain many rivers have cut deep and broad valleys, many of which have been still further deepened and widened by glacial abrasion. The trend of the most important of these valleys is either northerly or westerly. Among the more important northerly trending valleys, the Nitinat and Alberni valleys and the lower part of Klanawah valley have been widened and deepened by glacial scouring, while the others do not depart greatly from the V-shaped character. The more important east and west valleys are broad, this feature being in part due to glacial scour, but they are, however, subsequent valleys dating at least from Cretaceous times, as some of them are underlain by sediments referable to that period.

Alberni valley has been drowned, and it now forms the southernmost of the great fiords which indent Vancouver island from the west. Nitinat lake is only a few feet above low water, and at high tide the salt water rushes into it through a narrow rock gate. With the exception of these two inlets and two broad bays—San Juan harbour and Pachena bay—the west coast between Point Nopoint and Barkley sound is very straight and affords little or no shelter. This character, so unlike that of the coast north of Barkley sound, is due to the structure and uniformity of the comparatively recent Tertiary sandstones and conglomerates which form the greater part of this coast.

## Climate and Vegetation.

The climate of the area varies widely in different parts. Along the west coast it is exceptionally wet, with almost 120 inches of rain in a year, while on the east side of the island—in the lee of the main range—it is comparatively dry, with from 30 to 60 inches of rain per year. The temperature along both coasts is remarkably uniform, owing to the influence of the Japan current. The average temperature is 40° F. in winter, and 55° F. in summer. On the mountains the differences in temperature are, of course, much greater.

Virtually the entire area is heavily forested; the chief forest trees being fir, cedar, spruce, balsam, and pine. The timber is in places of little value owing to old windfalls, snowslides, and forest fires; but over large areas is of excellent quality. The western part of the area and the valleys are covered by a dense underbrush, composed chiefly of salalberries, huckleberries, and salmonberries, which, in places, are so thick as to be well-nigh impassable.

As yet there is little agriculture, and there is only a comparatively small part of the land suitable for farming purposes; not more than 10 per cent. Relatively narrow strips bordering the rivers and lakes furnish good land, which, however, must for the greater part be cleared of heavy, thick timber. Occasional, open meadow lands occur, especially in the interior.

## Means of Communication.

Fiords, lakes, and rivers, and a few roads furnish ready access to the interior of the island, and no very long inland trips need be made. Such trips at the present time must be made without the aid of pack animals, as the trails are not numerous and, with two or three exceptions, are only suitable for men.

## GENERAL GEOLOGY.

### Table of Formations.

A provisional classification, based on the past two seasons' field work, of the formations exposed on the southern part of Vancouver island, is as follows:—

| | |
|---|---|
| Superficial deposits | Pleistocene and Recent. |
| Sooke formation<br>Carmanah formation | Tertiary (Oligocene Miocene). |
| Cowichan group<br>Nanaimo, in part. | Upper Cretaceous.<br>(May include lower Cretaceous and Jurassic.) |
| Dike intrusion | Upper Jurassic? |
| Batholithic intrusion<br>Granodiorite.<br>Diorite and monzonite.<br>Sooke gabbro? | Upper Jurassic? |
| Vancouver group<br>Metchosin volcanics?<br>Mt. Sicker formation?<br>Sansum formation?<br>Vancouver volcanics.<br>Vancouver limestone. | Jurassic (or, and,) Triassic. |
| Victoria group<br>Nitinat formation.<br>Highland formation.<br>Leech River formation. | Upper Palæozoic?<br>Malahat? |

### General Description of Formations.

*Victoria Group.*—The oldest group of rocks in the southern part of Vancouver island is the Victoria group. This name was proposed by the writer to include the older metamorphic rocks that occur in the neighbourhood of Victoria,[1] and which were assigned to the Palæozoic, and provisionally, in part, to the Devonian, on the evidence of fossils secured at Cowichan lake. A later, much more complete collection of fossils from the same locality now shows the fauna to be either Triassic or Jurassic. The correlation of the formations is still doubtful, but it is probable that a large part of the rocks assigned to the Victoria group belongs to an older group of rocks than those in which the above fossils occur, and they are still assigned, provisionally, to the Palæozoic.

In the area explored during the past season, the following formations are exposed: the Nitinat limestones, the Highland volcanics, and the Leech River slates.

The Leech River slates form a belt of rocks 5 to 8 miles wide, extending westward from Leech river to the west coast. To the east of Jordan meadows, in the area examined in 1908, the belt narrows and is not exposed north of the Metchosin volcanics on the east coast. The southern contact, which is with the Metchosin volcanics, is a profound fault extending from the Royal Roads to the west coast near the mouth of Sombrio river; a distance of about 40 miles. The northern contact is marked by the San Juan valley and its eastward extension, Meadow creek. The contact is straight, and probably is a fault; in the eastern part of the area it is with the volcanics of the Highland formation, while towards the west it is with the Nitinat limestones.

1 Summary Report, 1908, Geol. Survey, Canada, p. 55.

The Leech River formation is composed chiefly of slates and slaty schists. Many of them are dark coloured, and graphitic schists are abundant. Greywackes and quartzose schists also occur. The rocks have a general eastward trend parallel to the strike of the belt as a whole. The dips are high and usually to the north. The beds are also contorted. It is probable that the entire formation has been folded into one or more close, nearly isoclinal folds.

In the eastern part of the area, the Leech River slates are in contact with closely-folded metamorphosed basic volcanics, chiefly tuffs and agglomerates, but including some porphyries. These rocks are provisionally assigned to the Highland formation. They are also exposed on the divide between the headwaters of Jordan river and Floodwood creek, with the Leech River slates on either side. They also form a belt lying north of the Leech River formation and extending from the North Fork of Leech river to Haro straits, east of Victoria.

The Nitinat formation occurs north of the Leech River slates, forming a belt 10 to 12 miles wide and extending westward from the mouth of Gordon river to Barkley sound, a distance of over 30 miles. The northern contact is with the altered volcanic rocks of the Vancouver series. The distribution of the rocks east of Gordon river is not known; possibly they may be represented farther east by the Malahat limestones.

The rocks of the Nitinat formation are calcareous. There are many areas of pure white, coarsely crystalline limestone, but a large portion of the limestone appears to have been profoundly altered by invading magmas into siliceous and feldspathic 'contact rocks' as well as amphibolites. The formation over wide areas has been replaced by the batholith of diorite and granodiorite, and the remaining areas are of the nature of huge 'roof pendants.' The strike is, in general, about N 65° W; the dips are all high.

*Vancouver Group.*—The Vancouver group embraces the great bulk of the crystalline rocks underlying the central part of the island. The group extends from the east coast to Alberni canal; in the central and western part of the area, the belt is 35 to 40 miles wide, but narrower to the east. The southern contact is with the Nitinat formation. In the eastward extension it may be with the Malahat formation, or the group may possibly include some of the volcanic rocks of the Highland formation. Along the northern boundary, the rocks are in unconformable contact with the Nanaimo group, which forms a relatively narrow band along the east coast.

The great bulk of the rocks of the Vancouver group are volcanics, chiefly basalts and andesites. They have all been metamorphosed and in part recrystallized, though not rendered typically gneissoid, and are seamed with quartz and epidote. Intrusive dikes and sills of fine-grained, basalt porphyrites occur.

Crystalline limestones in masses more of the form of rather large lenses than of beds, occur interbedded with the volcanics. The contacts are irregular, and small pieces of partially altered limestone occur within the basalt flows. The limestones are typically very finely crystalline, sometimes white or grey of colour but more commonly blue. They have been crushed, broken, and recemented by calcite veinlets. On the south shore of Cowichan lake, east of Croft creek, a lense of much less altered limestone occurs that in places consists largely of fragments of organisms.

North of Cowichan valley is a belt extending interruptedly from the east coast to near Alberni, which consists of shales and tuffs with interbedded porphyries and intrusive masses of gabbro-diorite porphyry. These rocks, described last year as the Mount Sicker series, undoubtedly form one of the formations making up the Vancouver group.

The Sansum formation is shown by Mr. J. A. Allan[1] to be conformable with the Mount Sicker formation, and hence belongs to the Vancouver group.

[1] See Summary Report of J. A. Allan.

Rocks similar to those of the Sansum formation are found in Chemainus valley, where they appear to be conformable with and transitional into the schists of the Mount Sicker series, yet cannot be separated from the shales of the Nanaimo group, and, therefore, though probably belonging in part, at least, to the Vancouver group, they are described under the general name of Cowichan group.

The Metchosin volcanics form the southernmost belt of crystalline rocks occurring south of the Leech River formation, and extend from the Royal Roads to the west coast. The formation consists entirely of volcanic rocks having a diabasic habit. They are much less altered than the volcanics of the Vancouver group, and contain no calcareous members, and, therefore, are only provisionally assigned to the Vancouver group.

The strike of the rocks of the Vancouver group, though locally varying greatly, is, in general, N 65° W, while the dips are high. The determination of the age of the group rests on their lithologic similarity to the rocks of the northern part of the island as described by Dawson and grouped by him under the name of the Vancouver series,[1] and on the fossils collected at Cowichan lake. This fauna, previously thought to be possibly Devonian, has, on the evidence of a more complete collection, been determined by Professor H. W. Shimer, to be upper Triassic or lower Jurassic.

*Batholithic intrusion.*—Intrusive into the Victoria and Vancouver groups are large plutonic masses. Although at the surface these masses are not usually connected, at a depth they probably are, since they are very similar in composition and relationship. The individual masses are often separated by very narrow belts of the overlying formations, and their outlines are very irregular.

As a whole, the batholith underlies the entire central part of the island. An almost continuous section of plutonic rocks occurs along Barkley sound and Alberni canal; while along the east coast, from Victoria to the central part of Saltspring island, they form a number of large bodies. Small masses have been intruded into a broad belt in the central part of the area near Cowichan lake, and to the south for 8 to 12 miles. A large body occurs in the catchment of the Franklin river and Granite creek, while the same general batholith is exposed to the eastward nearly to Ladysmith. Other similar intrusive masses are common throughout the area.

The chief rock type is granodiorite, though where intrusive in the Nitinat formation, diorite, sometimes monzonitic in character, is always in contact with the limestones. The diorite is cut by the more acid granodiorite. The granitic rocks have been broken and sheared extensively; many of them are gneissic, and all have been subjected to thermal metamorphism.

The plutonic rocks are intrusive into the Vancouver group, and the Nanaimo group (upper Cretaceous) rests unconformably upon them; they are similar to those of the Coast Range batholith and are correlated with them.

*Dike intrusions.*—With the exception of the volcanic intrusives, relatively few dikes were observed. A small number of andesitic and trap dikes cut the granitic rocks, and are apparently directly connected in origin with the batholithic masses. The Leech River slates are, however, intersected by irregular, fine-grained, basic dikes possibly not belonging to the same main period of igneous intrusion.

*Cowichan group.*—Throughout the region are long, trough-like areas of relatively unmetamorphosed sedimentary rocks belonging to at least two unconformable groups and possibly more. The different groups are, however, lithologically, very similar, and for the present are grouped together under the general name of Cowichan group. The members of this group occur in usually closely-folded, down-warped areas, and, being sediments and, therefore, more easily eroded than the crystalline rocks, occupy broad valleys which have, in general, a trend between N 60° W and N 80° W.

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[1] Dawson, G. M., Report on a Geological Examination of the Northern Part of Vancouver Island and Adjacent Coasts, Ann. Rep. Geol. Surv., Can., 1886, p. 10 B.

The principal area occurs along the east coast, where the rocks belong to the Coal Measures and contain the coal seams mined at Nanaimo and Extension. The other areas are in the Cowichan valley, the upper parts of Chemainus and Koksilah valleys, and Alberni valley.

The rocks of the Cowichan series are conglomerates, sandstones, and shales—the shales predominating. The basal members are conglomerates and sandstones, often composed of detritus from the basic volcanic rocks, and have a characteristic greenish colour. The shales are dark coloured and highly carbonaceous; in places they pass into slates and apparently into graphitic schists interfolded with the chlorite schists of the Mount Sicker formation.

In the Chemainus valley, and apparently also in the Koksilah valley, there appear to be two unconformable series of sediments within the group. The lower, consisting of shales and slates, is interbedded with tuffs and dacites of the Mount Sicker formation, and is cut by andesitic dikes and gabbro-diorite porphyry. These sediments should probably be correlated with the Sansum formation. They are overlain unconformably by a group of sedimentary rocks similar to those of the Cowichan valley.

The lower series exposed in the Chemainus valley almost certainly belongs to the Vancouver group, but the larger portion of the Cowichan group is clearly unconformable upon the Vancouver group and the granitic rocks, and is, therefore, of Cretaceous age. They may be of the same age as the Nanaimo group, that is upper Cretaceous, for they are apparently continuous stratigraphically to the east coast where the rocks are almost certainly of the Nanaimo group. They are, however, more metamorphosed than the rocks of the Nanaimo formation, and are, apparently, not coal-bearing.

*Carmanah and Sooke Formations.*—Along the west coast, from Beecher bay westward nearly to Pachena bay, occurs a narrow strip of sediments, chiefly conglomerates and sandstones, of Tertiary age. They have been divided by Merriam[1] into the Carmanah and Sooke formations.

The Tertiary sediments form a series of elongated basins seldom more than a mile in width, separated by relatively narrow ridges of the underlying crystalline rocks. The sediments consist of coarse basal conglomerates and sandstones with, in the larger basins, thin-bedded, shaly sandstones and occasional thin lignite seams. The beds are comparatively undisturbed, with gentle dips to the southwest, usually under 10°. The entire thickness of the sediments in any one basin is probably not more than 500 feet, but though lithologically similar throughout, the sediments of the eastern basins contain a stratigraphically higher fauna than those of the western basins, so that Merriam divided them into the Carmanah (Astoria Miocene) and Sooke (upper Miocene or lower Pliocene) formations.

## ECONOMIC GEOLOGY.

The ascertained value of the mineral deposits of the district, excluding the coal deposits of the east coast, is not large. The greater part of the area is still unprospected, as prospectors have only explored the principal streams and the shores of the lakes. The development work on the majority of the prospects has been small. The metals that have attracted attention are gold, copper, and iron; silver, lead and zinc ores have been reported. Other deposits of possible value are those of sulphur, coal, fluxes, clay, and building stone.

### Gold.

Gold has been known to occur in the Leech river since the sixties, and the gravels and sands near the mouth of the Sombrio river have been known as a source of gold since the days when the Spaniards explored the Pacific coast in the latter part of the

[1] Merriam, J. C., Bull. University of Cal., Vol. 2, No. 3, pp. 101-108, 1896.

eighteenth century. Gold is known to occur throughout the Leech River valley, and is supposed to have been derived from the quartz veins in the Leech River slates.[1] Both the gravels in the actual valley and the higher gravels of the tributary creeks to the north of the valley are known to be auriferous, but the deposits are not extensive and so have not been considered economically important.

A large accumulation of gravel and sand occurs on the coast, near the mouth of Sombrio river. At the present time a partnership composed of Messrs. R. S. Gallop, D. W. Hanbury, and W. H. Kirkbridge, has been formed to build a hydraulic plant to work these gravels, the plant being under course of construction during the past summer. The amount of gravel has been estimated by an engineer employed by the partners to amount to 3,000,000 cubic yards, and as sampled from a bank on the shore, is considered by Mr. Gallop to run over 50 cents a cubic yard. Some of the gold is flaky and fine, but the bulk is apparently fairly coarse.

Auriferous gravels occur in the numerous valleys of the small streams crossing the slate belt, but, as a rule, the amount of gravel is very small. The deposits of gravel in the San Juan valley are probably low grade, as they are largely of glacial origin. Along the west coast in the vicinity of Sombrio river and to the east as far as Jordan river, black sands occur in the beach, and carry gold. The gold is, however, flaky, and the actual amount of black sands is apparently not large. Mr. Gallop, who has prospected the gravels and sands in the neighbourhood, reports the occurrence of native mercury in the sands.

Though it is believed that the gold of the gravels and sands has been derived from the quartz leads in the slate belt, the writer is confident that the quartz veins so far examined are too low grade to be of economic importance.

Placer gold has been sought in Franklin river and China creek, but has not been found in paying quantities.

Mineralized shear zones occur along the contacts of the limestones and volcanics with diorite and granodiorite. The deposits of this character are usually more important as possible sources of copper, but they also carry small amounts of gold. A typical example is that of the deposit on the Alfreda claim, situated on the east slope of the valley of Gordon river 3 miles above the mouth. Here, the diorite, which includes a block of what has probably been limestone, has been tremendously sheared, forming a zone about 25 feet in width and striking N 50° W. The diorite and limestone have been completely changed to a chlorite and to a graphitic chlorite schist. In this zone lenses of quartz carrying a small amount of pyrite have been developed. The rock is said to assay $2 a ton in gold and 5 ounces of silver. Unless considerably larger and higher grade bodies are found, these deposits are of little or no commercial importance.

## Copper.

The deposits of copper-bearing minerals which were examined during the past season are all intimately connected with the granodiorite and diorite batholiths, and usually occur in contact metamorphosed limestones adjacent to the igneous rocks. In these zones the metallic minerals occur as rather small, irregular bodies of magnetite, pyrrhotite, pyrite, and chalcopyrite; intimately associated in most cases with garnet, or they occur disseminated through shear zones at or near the contact. Shear zones in the metamorphosed basalts and andesites also occur, which have been impregnated by copper-bearing minerals. A less important type is that in which chalcopyrite occurs in distinct quartz veins lying in shear zones; notably in the old volcanic rocks.

The contact deposits occur in both the coarsely crystalline limestones of the Nitinat formation and in the compact blue, crystalline limestone lenses which are interbedded with the volcanic rocks of the Vancouver group. They might also be divided into two groups, those which are situated at the contact, and those which

[1] Clapp, C. H., Summary Report, Geol. Surv., Can., 1908, p. 59.

occur higher up in the contact metamorphosed limestones. The former are characterized by a higher percentage of magnetite and pyrrhotite, and the latter by a higher percentage of pyrite and chalcopyrite.

The contact deposits in the Nitinat marbles are rich in magnetite and are of more value for the iron they contain than the copper. The most important of these deposits, those along the Gordon river and Bugaboo creek, are described under the iron deposits. In Barkley sound, deposits containing copper minerals occur on the islands, and also in the Sarita valley about 2 miles above the mouth. The limestones have been altered to the characteristic diopside-garnet rock, and the siliceous and feldspathic 'contact rock,' locally called 'felsite.' They have also been sheared to a great extent. Pyrrhotite is the chief metallic mineral. It occurs disseminated through the sheared rock, often replacing it so as to form irregular masses of nearly pure sulphide. Associated with the pyrrhotite is more or less magnetite, and also chalcopyrite, which occurs as disseminated grains and small gash veins in the pyrrhotite. Sometimes the veinlets or lenses furnish a very high grade ore, but they are small, usually less than an inch in thickness, and none were seen that were more than 6 or 8 inches in width. The deposits are irregular, essentially low grade, and none of those examined are more than a few feet in thickness. The present economic value is, therefore, slight.

Considerable development work has been done on the Sarita River deposit.

Several deposits occur in the limestones of the Vancouver group in the neighbourhood of Cowichan lake. Those above the headwaters of the East Fork of the Robertson river are located near the contact with granodiorite or quartz monzonite. The greater part of the limestone has been metamorphosed to an amphibolite; but when the metallic minerals occur abundantly they are associated with a garnetiferous rock, called by the prospectors garnetite. Higher up, on the ridge, white, crystalline marbles, which are fairly pure, are found. On the 'Hillside' claim, located 400 feet above the river, a body of pyrrhotite and chalcopyrite, 3 feet wide, occurs in the garnetiferous rock. The chalcopyrite occurs in veinlets and lenses in the pyrrhotite up to 8 inches thick. The deposits near the river on the 'Alpha' and 'Beta' claims consist of disseminated magnetite and chalcopyrite in the garnet-bearing rock. The metallic minerals have sometimes replaced the metamorphosed limestone, and on the 'Alpha' claim, near the discovery post, a body 6 to 8 feet wide has been exposed, consisting chiefly of chalcopyrite with some magnetite and garnet. The paragenesis of the minerals is clearly shown in many cases to be magnetite, garnet, and chalcopyrite. The garnet is, however, of more than one order of formation. Some of it occurs as small well developed crystals of green andradite, while the copper pyrites occurs filling the interstices between the garnet grains.

The deposits are not deeply weathered, and the unaltered sulphides occur within a few inches of the surface. Pyrrhotite is often spoken of incorrectly among the prospectors as an 'iron cap,' and they refer to it as if it capped a body of nearly pure copper pyrite. This is a wrong interpretation of the facts, as there can be no enrichment of copper below the surface by the formation of pyrrhotite, as there is when a typical 'iron hat' or gossan is formed. It is readily seen that pyrrhotite has been formed before the chalcopyrite, and as far as the investigations on the copper deposits of the island have gone, pyrrhotite cannot be taken as a good indication of the presence of any large quantity of chalcopyrite. Where the pyrrhotite is not abundant the deposits are at least very favourable prospects.

The contact deposits which have apparently been formed at a higher zone of the contact, occur on Mount Gordon, at the headwaters of the Gordon river, and on the south slope of the Alberni canal near the entrance. The deposit on Mount Gordon may be taken as typical. It occurs a little over a mile west of Gordon bay (Cowichan lake), and several claims have been located on the deposit. It occurs in a contact metamorphosed and much sheared bed of dense blue, crystalline limestone, which is interbedded with sheared and altered basic volcanic rocks. The granitic rocks causing

the metamorphism are not exposed in the immediate vicinity, but doubtless occur at no very great depth. The metallic minerals are pyrite and chalcopyrite, with garnet and quartz as the chief gangue minerals. The absence or small amount of magnetite and pyrrhotite is significant, and apparently shows that the mineralization has taken place at a distance from the actual contact. The garnet zones are narrower and the ore minerals occur most abundantly in the sheared rock, largely altered to a chlorite schist. In the deposit of the Gladys mine, Alberni canal, bladed amphiboles have been formed in the sheared rock. There are small lenses of chalcopyrite in the sheared rock, as well as disseminated grains. The deposits as a whole are low grade, but owing to the absence of magnetite and pyrrhotite, they are one of the more promising types of contact ore bodies.

Some ore has been shipped from the Gladys mine, but as the ore was gouged out without developing the property, it is impossible to gain a fair idea of the extent of the deposit. As a rule the deposits are probably small and irregular.

All of the above types are clearly of contact origin. The proofs are apparently indisputable that the metallic contents were derived from the invading magma. In most cases the original limestone has not only been changed mineralogically but chemically. The definite order of crystallization of the minerals forming the ore deposits shows that they were deposited from solution, and the change in character of the deposits in the higher zones apparently shows—since they contain the last of the metallic minerals to crystallize—that there has been an upward circulation. The nature of the minerals indicates that they have been formed at high temperature and pressure. It is, therefore, most probable that the deposits were formed by emanations from the invading magma.

A contact deposit of somewhat different peculiarities occurs on the divide between the Chemainus river and Cottonwood creek, and has been developed on several claims. The deposits occur in a series of thin-bedded, silicified shales, and quartzite-looking rocks. They are apparently interbedded with the meta-basalts and andesites which occur to the south. They have a general strike of N 45° W, and a dip of about 40° to the southwest. These rocks are cut by dikes and sheets of, or possibly interbedded with, feldspar porphyry. The entire series is cut by granodiorite which underlies the ridge on which the deposits occur at a very shallow depth and is exposed on the slope down to the Chemainus river. These rocks are very similar to those which occur north of Cowichan harbour, exposed along the Sansum narrows, and which were described last year under the Mount Sicker series. They were thought to be largely of volcanic accumulation, with interbeds of shale.

The metallic minerals occur along certain zones, which are characterized by the development of garnet. The garnetiferous beds are interbedded with slaty rocks thought to be tufaceous. The garnet is the lime-iron garnet andradite. The garnetiferous beds are impregnated with pyrite and chalcopyrite, which sometimes occur as lenses or veinlets with or without calcite. Quartz and molybdenite are usually present. Conspicuous in some of the mineralized zones are massive magnetite and pyrrhotite.

The nature of the deposit, characterized by andradite garnet, suggests very strongly that it is a limestone contact. No limestone or marble, distinctly recognizable as such, is, however, exposed in the vicinity. Up to the time of the examination, no limestones or calcareous rocks had been seen in this belt, which apparently extends along the north side of the Cowichan valley more or less continuously to the shore. Later in the season limestones—white marbles—were found in the same belt, but always associated with massive volcanic rocks. The banded rocks were considered last year to consist solely of altered volcanics and shales, and this conclusion was confirmed by Mr. Allan's detailed work north of Cowichan harbour. At the time of the examination the writer was, therefore, quite certain that the deposit was formed by emanations from the underlying granodiorite batholith, in a series of volcanic tuffs, porphyries, obsidians, and shales of sedimentary origin, which rocks had been silicified

and altered by the contact metamorphism. A qualitative examination of the garnet has shown it to be the lime-iron garnet, and a hurried microscopic and qualitative examination of the rocks shows the presence of considerable calcite, which also occurs in the veins, so that it is possible that the garnetiferous bands represent beds of limestone, which were probably impure.

In the schistose andesites and dacites that make up the western extension of the Mount Sicker formation, several claims have been located in sheared zones which have been impregnated with pyrite and chalcopyrite. In all these sheared zones pyrite is much more abundant than chalcopyrite, and the deposits are apparently of little value.

On the 'Brass' mineral claim, of the Jubilee group, a shaft has been sunk on a quartz vein, 18 inches wide, and traceable for about 50 feet along the outcrop. The vein carries pyrite and chalcopyrite, pyrite being greatly in excess. The vein occurs in a mineralized shear zone in the altered basalts or andesites of the Vancouver series.

Similar impregnated shear zones occur in the volcanic rocks exposed along the Nitinat river. Pyrite is the principal metallic mineral. On the surface the whole impregnated zone weathers to deep reddish-brown, so that the mineralization appears superficially to be much more extensive than it really is. Deposits of this type are of little or no value.

In the Metchosin volcanics, shear zones with accompanying quartz stringers which carry metallic minerals occur. A deposit on one of the tributaries of the Jordan, about 3 miles from the mouth, occurs in a dense ophitic basalt, which has been impregnated and replaced along narrow shear zones—the strikes being N 25° E and N 60° W—chiefly by pyrite, with some pyrrhotite and chalcopyrite. These minerals are massive. Cutting the shear zones are quartz stringers up to 4 inches wide. These contain small crystals of pyrite and chalcopyrite. The deposits are small, very low grade, and are apparently of no economic value.

A large number of claims have been staked on a group of deposits occurring at the headwaters of the Franklin river and China creek. These claims were not visited, and their character is not known.

### Iron.

On the Gordon river and its tributary, the Bugaboo creek, which empties from the west into the main river about 6 miles above the mouth, are developed large bodies of magnetite which have been exploited for iron. These deposits occur in coarsely crystalline limestones near the contact with diorite.[1]

There are several belts, at least five, of limestone, which are separated by diorite. The diorite, which is apparently a peripheral phase of the granodiorite batholith, is intrusive into the limestone, and is itself cut by the granodiorite. The limestones were originally pure, to judge from the large beds of pure white, coarsely crystalline marble that are found. They have been tremendously altered by the invading batholith, which is to be expected, since the belts of limestones are only 75 to 200 yards wide, and are of the nature of 'roof pendants.' The large one, in which the principal ore deposits are developed, is continuous for at least 3 miles, having a strike of about N 70° W. It is parallel to Bugaboo creek, and occurs on the southern slope of the Bugaboo valley. The limestone has been in part changed to the ordinary siliceous garnet-diopside rock so characteristic of limestone contacts. Much of it has been more profoundly altered to an amphibolite consisting chiefly of hornblende and feldspar.[2]

The igneous rock itself has apparently been subject to change. Although the chief rock type of the batholith is granodiorite, no granodiorite has been noted in direct contact with limestone. The igneous types at the contact are chiefly diorites, some of

[1] The deposits have been described by E. Lindeman, Summary Report, Mines Branch, 1907-8, pp. 36-37.

[2] Compare F. D. Adams. On the origin of the Amphibolites of the Laurentian Area of Canada. Journ. of Geol., Vol. XVII., No. 1, pp. 1-18, 1909.

them monzonitic in habit. At the actual contact a very dark diorite occurs, extremely rich in femic minerals. Since this is a feature only of the limestone contacts, it is to be presumed that the limestone had a profound influence on the invading igneous rock.

Along the Bugaboo Creek belt, as well as along the other smaller strips of limestone, large masses of almost pure magnetite have been found. These vary in size up to masses such as are exposed in the Baden Powell claim, which is 125 feet wide, and about 500 feet in length on the outcrop. The magnetite, although nearly pure, is cut by great numbers of veinlets of pyrite and chalcopyrite. An average of the three analyses from these deposits given by Lindeman[1] is as follows:—

| | |
|---|---|
| Silica | 7·300 |
| Iron | 60·850 |
| Sulphur | 2·550 |
| Phosphorus | 0·048 |

This, doubtless, fairly represents the better grade of deposits.

An interesting feature is exhibited at the contact of the magnetite body and the marble, which lies below the magnetite, on Bently creek. Apophyses of magnetite have penetrated the pure marble much as apophyses of an igneous rock would an invaded formation. Irregular tongues penetrate and have included fragments of the limestone.

The nature of the deposit is such that there appears little doubt but that the batholith must be looked to for the source of the metallic contents. That the metallic minerals, especially the magnetite, were deposited from very concentrated solutions, is strongly suggested by the intrusive veins exposed on Bently creek.

Other deposits of a similar nature are known to occur in the same formation south of Sarita river, as well as in the more northerly portions of the island.

That the deposits are large and extensive is strongly supported by their occurrence, and by the development work which has already been done. The high percentage of sulphides is extremely undesirable, and will doubtless always be present. Lindeman[1] writes, however, that it is not too high to render the ores unfit for smelting.

## Sulphur.

The contact deposits which are rich in sulphides, especially pyrite and pyrrhotite, are possible sources of sulphur. No such deposits were seen in the area examined last summer which were large enough or rich enough in sulphur to be considered as even possible sources of that substance.

## Fuels: Coal.

Along the eastern coast of the island the Nanaimo formation occurs, which contains the coal seams which are the source of the extensive industry at Extension and Nanaimo. Large areas of sedimentary rocks of similar lithological characters occur in the region examined this season. These are: the basins underlying the Chemainus river, the Cowichan valley, the upper part of the Koksilah, at Alberni, and a narrow strip along the west coast. These sediments, on account of their lithological similarity to the Coal Measures of the east coast, have been prospected sporadically, yet sometimes quite extensively, for coal. The prospectors have often been encouraged by the presence of very thin coal streaks, or thin lenses of lignite, yet in no case have any deposits of even prospective value been found.

The sediments which fringe the west coast are of Tertiary age (Miocene), and it is evident from the fauna they contain that they are of marine origin. The entire

[1] Ibid.

thickness of the formation which occurs on Vancouver island is not great—probably less than 500 feet. They extend only a short distance inland; in one or two instances over a mile, but usually much less. Almost the entire thickness is fairly well exposed, and no coal is shown. A few thin lenses of lignite are known. Similar deposits in the sediments to the east were considered last year to be of drift origin,[1] and the evidence gathered during the past season bears out this conclusion. It is virtually an assured fact that, these sediments do not contain workable beds of either coal or lignite.

The other sedimentary areas are much older, and may in part belong to the Nanaimo group. However, at the present time, from evidence given in the above section on general geology, it seems probable that part of the sediments belongs to lower formations than the Nanaimo: either lower Cretaceous or Jurassic. Fossil remains of plants, and even thin seams of coaly material, $\frac{1}{8}$ to $\frac{1}{4}$ of an inch thick, are found. No larger seams are known. The sediments have been much more folded and metamorphosed than the known Cretaceous Coal Measures, and are cut not only by basic dikes, but possibly by granitic rocks. From the data on hand, it seems improbable that coal of any great importance occurs in these beds.

## Fluxes, Lime, and Cement.

The crystalline limestones afford abundant material suitable for fluxes, also for the production of lime, and for the manufacture of Portland cement. The more compact, finer grained, often blue limestones which occur as lenses in the great mass of volcanic rocks which make up the Vancouver series, are on account of their much smaller size, the altered character of the material, and the numerous dikes or interbeds of porphyry, of less importance. On the other hand, the coarsely crystalline marbles of the Nitinat formation have been profoundly altered by the invading batholith, so that by far the larger bulk of the limestones of this formation is useless for any of the purposes mentioned. However, large belts of relatively pure unaltered marble occur, such as that exposed at the southern end of Nitinat lake to the northeast of the Indian reservation, which afford an ample supply for the establishment of a large industry. At present, none of the marbles of the district are utilized. The only attempt to utilize them was made in the belt exposed on the eastern shore of the Alberni canal opposite Nahmint bay. Although the limestone is apparently of good quality for lime, the attempt was given up without even quarrying much limestone, or burning any.

## Clays.

In this district, as in the area examined last season, only low grade clays occur, and these are confined to Pleistocene and recent deposits. None of the shales of the Cowichan series exposed in the area offer suitable material. Most of them have been more or less metamorphosed, and they are all sandy and impure. The superficial clays, largely modified glacial detritus, are also sandy and impure; although some of them, such as those in the neighbourhood of Alberni and those underlying the flat areas and meadows along the west coast and in the principal valleys, would perhaps be suitable for common brick, tile, and the cheaper grades of stoneware. The clays are not used at all, as there is at present no local market, and the wares would not be of such quality as to stand high transportation charges.

## Building and Ornamental Stones.

The fractured and sheared character of the formations of the entire district renders the great majority of the rocks useless for building stones. In relatively rare instances the marbles may have escaped fracturing to such an extent that blocks of

[1] See Summary Report, Geol. Surv., Canada, 1908, p. 60.

a fair size may be obtained, and it is very probable that the size and quality of such blocks would improve with depth. The granitic rocks have likewise suffered from the general shearing. However, along the Alberni canal, notably north of Franklin river, a basic granite (granodiorite) occurs which is massive, regularly jointed, and is apparently quite free from small fractures, and which would possibly make a good building stone.

Other stones available are the coarse, thick-bedded sandstones of the Tertiary sediments along the west coast, and some of those of the Cowichan series. In no case does the sandstone seem to be of such a quality as to admit of its profitable export to an outside market, but it might be used for local constructional purposes.

The traps, especially those of the Metchosin formation, offer abundant material for an excellent quality of crushed stone.

# SALTSPRING ISLAND, AND EAST COAST OF VANCOUVER ISLAND.

*(J. A. Allan.)*

## LOCATION AND AREA.

The district examined this summer lies on the eastern side of Vancouver island, about 25 miles north of Victoria, between Cowichan harbour on the south and the town of Ladysmith on the north. On the main island this area is about 20 miles long and 4 to 6 miles broad. The southern two-thirds of Saltspring island, comprising an area of about 70 square miles, was also examined. The northern portion of the island was not visited, as it is underlain by rocks of the Nanaimo group—Coal Measures—and an examination of these rocks was not included in the work outlined. The total area covered was between 175 and 200 square miles.

The season's work was, for the most part, of a detailed nature, and occupied the first two months of the field season, of which the first three weeks were spent on Saltspring island. A large part of the area examined is accessible inland by roads, and by boat along the coast. Saltspring island was examined largely from a boat traverse around the shore.

## GENERAL CHARACTER OF DISTRICT.

The general relief is low; the greatest elevation being that of Mount Bruce, 2,300 feet above the sea. The hills have well rounded tops, due in part to the action of ice. The slopes are generally steep, are more or less densely wooded, and have a rank undergrowth.

A ridge with a relatively flat top strikes N 70° W across the area, and includes Mount Bruce, Maple mountain, Mount Sicker, and others. On either side of the ridge are flat-topped hills, such as Mount Baynes, Mount Erskine, Mount Tzouhalem, and Mount Prevost.

The valleys in the area run in two directions: the principal ones have a northwest and southeast trend, while others run north and south. On the mainland the Cowichan and Chemainus are the principal valleys. On Saltspring island two well marked depressions with a northwest and southeast trend, divide the island into three rectangular parts. One of these depressions extends from Fulford harbour to Burgoyne bay; the other connects Ganges harbour with Vesuvius bay, and is represented on the mainland by Oyster harbour at Ladysmith.

There are few large streams in the area, this being especially true of Saltspring island. The water is drained off immediately by small, intermittent streamlets. On the mainland, Cowichan and the Chemainus rivers are the only large streams. The first named empties into Cowichan harbour, and with the Koksilah river, which comes from the southwest, forms at its mouth an extensive mud flat. Chemainus river has also built up a broad, fertile, mud flat, over a mile wide, at its mouth.

## GENERAL GEOLOGY.

The rocks of this area may be provisionally classified as follows:—

| | |
|---|---|
| Superficial deposits.. .. .. .. .. .. .. .. .. | Pleistocene and Recent. |
| Cowichan group (Nanaimo, in part).. .. .. .. | Cretaceous (in part). |
| Dike intrusions.. .. .. .. .. .. .. .. .. .. .. | Cretaceous (in part). |
| Saanich granodiorite.. .. .. .. .. .. .. .. .. | Upper Jurassic? |
| Mt. Sicker formation (Vancouver group).. .. | Triassic-Jurassic. |
| Sansum formation.. .. .. .. .. .. .. .. .. .. | Triassic-Jurassic. |

*Mount Sicker Formation.*—The Mount Sicker formation occupies a belt lying north of Cowichan harbour, which, at Sansum harbour, is 5 miles wide. Westward it underlies Maple mountain, Mount Richards, Mount Sicker, and Mount Brenton. At the foot of Mount Sicker the belt narrows to less than a mile in width, but to the west broadens out again. On Saltspring island it underlies a portion of the central part, but is intruded, and replaced in part, by granodiorite. Interfolded with the Sansum shales, it underlies the southern third of the island.

The Mount Sicker formation consists of dacites, augite-andesites, and andesite-porphyries, extensively altered to chloritic, quartzose, and talcose schists. Rounded, yellowish-green nodules of epidote are very common in these schists, giving them a 'knotted' appearance. A group of basic porphyritic rocks belonging to diorite and gabbro-diorite types, has been intruded into the series. Some are intrusive along the planes of schistosity, while others cut across these planes.

The formation has been intensely metamorphosed and closely folded along axes having a general strike N 70° W. Dynamic and thermal metamorphism has altered the rocks to schists. In this belt more or less mineralization has taken place, and in it the well-known copper deposits of Mount Sicker occur.

As no fossils have yet been found in the Mount Sicker rocks, it is difficult to say definitely to what age they belong. Since there is an undoubted unconformity between at least the higher divisions of the Cowichan group and the Mount Sicker formation; and since the upper part of the Cowichan group as seen on Saltspring island, apparently belongs to the Nanaimo group (upper Cretaceous), it is evident that the Mount Sicker formation is older than upper Cretaceous. The Mount Sicker formation is cut by the Saanich granodiorite, which has been correlated with the Coast Range batholith of upper Jurassic age; it is, therefore, probable that the Mount Sicker rocks are Jurassic or Triassic in age, and that they are one of the series that comprise the Vancouver group as defined by Dawson, and limited by Clapp.

*Sansum Formation.*—To the south of the schistose rocks of the Mount Sicker formation, shales occur, more or less metamorphosed and with interbedded argillites, tufaceous rocks, and sheets of andesite and dacite. Toward the south the shales are unaltered, and to these unaltered beds the name, Sansum formation, has been given; while those which are interbedded with the volcanic rocks have been grouped, provisionally, with the Mount Sicker formation. Where the shales are interbedded with the tufaceous rocks the contact is indistinct, but there is no doubt that the two types merge into one another. The unmetamorphosed shales are soft, black, and very fine in texture, with a peculiar concretionary form of weathering in certain beds. This type of weathering is also characteristic of many of the shales of the Cowichan series. Pyrite is common in the shales, and numerous impregnations are frequently found arranged parallel to the bedding planes.

Field evidence seems to show that the shales and tuffs underlie and grade upwards into the greenstones. This would make the greenstones younger than the shales and tuffs, contrary to the results obtained by Clapp[1] on the Chemainus river. Before the relative ages of the two groups can be definitely decided, it will be necessary to examine more closely the areas to the north of Mount Sicker, and along Chemainus river. Bands of graphitic schists and sandstone are found toward the southern part of the area occupied by the series, also conglomerates containing well rounded pebbles of fine-grained sediments and volcanic material which may have come from the Victoria group.

*Saanich Granodiorite.*—Intrusive into the Mount Sicker and Sansum formations is an irregular mass of granodiorite, called the Saanich granodiorite. This rock varies from a quartz-rich granodiorite to a diorite. On Saltspring island there are approximately 20 square miles of the granodiorite exposed. This batholith forms

1 Clapp, H. C., Geol. Survey, Canada, Summary Report, 1908, p. 56.

a contact breccia with the Mount Sicker rocks on Saltpsring island; and at Ladysmith apophyses of the granodiorite were found cutting the older chlorite and amphibole schists. The extent of the granodiorite was not determined about Ladysmith. This granodiorite batholith may be correlated, provisionally at least, with the Coast Range batholith of upper Jurassic age.

*Dike Intrusions.*—Dikes are not numerous in this district; a few trap and andesite dikes, none more than 3 feet wide, cut the intrusive granodiorite and the older rocks.

*Cowichan Group.*—The Cowichan group, as defined by Clapp,[1] is made up of those conglomerates, sandstones, and shales which cannot be definitely assigned to the Sansum formation. The group consists of at least two unconformable series, and perhaps three. The lower division, which is exposed in this area, undoubtedly belongs to the Nanaimo group, as defined by Dawson,[2] and as mapped by Richardson.[3] On Saltspring island these rocks are found to the north of Burgoyne bay; while to the west, on Vancouver island, they underlie the Cowichan valley, and at Mount Prevost are overlain unconformably by sediments apparently belonging to the Upper division of the Cowichan group, or else belonging to the lower, and their present position is due to overthrust faulting.

The succession of this lower division of the Cowichan group is, in ascending order, conglomerate, sandstone, and shale. To the north of Cowichan harbour the sediments strike N 45° to 55° W, and dip 10° to 20° N. The dip increases northward, and at Maple bay it is about 70° N; the shales are here faulted off against the Mount Sicker rocks. In this locality the conglomerates are distinctly unconformable upon the Sansum shales and the Mount Sicker formations, which are dipping steeply. No evidence of extensive overthrusting is visible, and the conglomerate at the base contains very large boulders of the underlying volcanics, fragments of the metamorphosed shales, and occasional boulders of Saanich granodiorite.

On Saltspring island the same succession is found; Mount Baynes is capped by 700 feet of conglomerate lying unconformably upon the granodiorite, and made up almost entirely of boulders and well-rounded pebbles of granodiorite, granite, and quartz. The conglomerate dips slightly to the north, and is seen to fill up the depressions of the old erosion surface of the granodiorite. The same is seen at Beaver point, on the east of the island, where the conglomerate is in contact with the underlying greenstones of the Mount Sicker formation. Continuing northward, Mount Erskine and Mount Belcher consist of conglomerates interbedded with sandstones, and dipping 25° to 35° northeast. To the north the sandstones and shales have been folded into a syncline, or several small ones, underlying the depression between Ganges harbour and Vesuvius bay (Booth bay). Beyond this the series again have a northerly dip.

*Superficial Deposits.*—The greater part of the area is deeply covered with glacial detritus. There are also occasional Pleistocene and recent alluvial deposits. Some of these along the present shore-line are at least 100 feet deep; the upper beds in some places consisting of fine sand. The wave action is rapidly washing away these recent deposits, and as a result the shore is lined with out-fallen trees. Extensive alluvial flats are found at the mouth of the Chemainus and also of Cowichan river.

## STRUCTURAL GEOLOGY.

The rocks of the Sansum and Mount Sicker formations are tightly folded, and in several places faulted. The axes of folding have a strike of N 35° to 75° W, with a general direction of N 60° to 70° W. In general, the dip is toward the south. Fold-

1 Clapp, C. H., Geol. Survey, Canada, Summary Report, 1909.
2 Amer. Jour. of Sci., 3rd Series, Vol. 39, p. 180, 1890.
3 Geol. Surv., Canada, Annual Report, 1876-7, p. 170.

ing is especially well seen on the southwest shore of Saltspring island, south of Burgoyne bay. Three distinct synclines there occur in a distance of about 4 miles. These synclines are composed of many smaller folds and contortions.

All the formations in the area have been broken by a series of faults which correspond to the general axes of folding. Particularly conspicuous is one cutting across Saltspring island between Fulford harbour and Burgoyne bay. On the north side of this fault the granodiorite occurs to an elevation of 1,300 feet, and is capped by 700 feet of Cowichan conglomerate, so that the displacement here has been very great. This break continues across Sansum narrows to Maple bay, and forms the contact between the Mount Sicker formation and the Cowichan group. Another parallel fault plane forms an escarpment in the central part of Saltspring island, to the north of Cusheon lake, and on which Mount Erskine and Mount Belcher are situated. This fault line may be connected with one running from Horseshoe bay to the mouth of Chemainus river. Another fault plane, parallel with these two, is exposed at the northeastern end of Cowichan harbour, and is probably the cause of the escarpment on the southwest side of Mount Tzouhalem, and possibly of the Cowichan harbour. Faults of smaller magnitudes are also numerous.

## ECONOMIC GEOLOGY.

### Copper and Iron.

In this district mineralized zones of shearing lie in highly metamorphosed igneous rocks of the Mount Sicker formation. Most of the more important deposits are of value on account of their copper contents; but in some cases magnetite is the valuable mineral, while many of the sheared zones are highly impregnated with well-crystallized pyrite.

On Mount Richards considerable mineralization has taken place. The ore consists of chalcopyrite, pyrite, and some sphalerite; bornite occurs very sparingly, and copper glance is reported. The gangue minerals are largely quartz with some barytes. Quartz alone sometimes occurs as veins in the sheared rock. The conditions here are similar to those on Mount Sicker. The ore deposits are intimately connected with the gabbro-diorite-porphyry and with the metamorphosed volcanics. The nature of the alteration of the country rocks suggests that the minerals, in some cases at least, have been brought in by heated solutions.

A large area—about 2 square miles—of diorite-porphyry, on Mount Richards, to the north of the Lenora railway, contains finely disseminated particles of chalcopyrite (and probably some chalcocite), to such an extent that, in almost any part of the mass, it is said to assay as high as one per cent in copper. The sulphides have also become segregated out along certain sheared zones. No work is being carried on at present, and the development to date consists of a number of small prospect holes. The most work has been done on the Iron Clad, Ureka, Lord Roberts, and Jena mineral claims.

The Iron Clad seems quite promising, but sufficient development has not yet been done to warrant a definite conclusion. The deposits are necessarily low grade; but it might be suggested that further prospecting along the contacts is advisable—especially between the more basic diorite and the sheared rocks. The rock along the sheared zones is sometimes quite talcose, and in one of the shafts, at the 30 ft. level, a 3 ft. vein of talc is said to have been exposed.

On the northwest slope of Mount Sullivan, on Saltspring island, magnetite occurs in a sheared zone in highly schistose rock. The zone is about 100 feet wide, and is filled with very finely crystalline jasper, giving the rock a reddish appearance. The iron ore is found chiefly toward the centre of the zone, and generally in narrow bands of almost pure magnetite; the widest one noted was 3 inches broad. The magnetite also occurs in irregular lenses surrounded by microcrystalline quartz.

Some of the magnetite has changed to hematite. The zone contains fragments of the sheared rock in it, and numerous, minute seamlets of quartz, while sulphides are absent.

## Non-metallic Deposits.

A brief note is sufficient on the non-metallic deposits in this area. A small plant at Somenos is manufacturing common brick from the deep clay deposits which extend from Mount Sicker to Cowichan river. The alluvial deposits along the shore would doubtless furnish material for good, common brick, tile, and a cheap grade of stoneware.

The sandstone to the south of Vesuvius bay was the material used in the construction of the dry docks at Victoria. It is a light-grey variety, and readily weathers to brown. It varies in texture from fine to very coarse. The beds are thick and massive, and are situated on the shore of the bay, so that the rock can be quarried at small expense.

## TOPOGRAPHIC WORK ON VANCOUVER ISLAND.

*(R. H. Chapman.)*

Field work in connexion with the preparation of a topographic map of Vancouver island began early in June, and continued with little delay until November. Topographic maps were completed over the region adjacent to the city of Victoria, the whole of the Saanich peninsula, a small part of Saltspring island, and many of the smaller nearby islands, comprising a total area of 150 square miles. Triangulation, level lines, and road surveys were made in an area adjacent to Nanaimo, in the direction of Ladysmith, but the topography was not finished, as bad weather set in and field operations were discontinued.

At first, one large party was organized, which operated in the vicinity of Victoria, but as the season advanced this party was divided until there were three, and finally four, parties working in widely-separated localities.

It was necessary to begin by obtaining a number of points to which the elevations and positions on the maps could be referred. This was done by extending triangulation control from points on hills near Victoria which had been located many years ago, and by level lines, run with engineers' level, starting from a bench-mark near the old Custom House in Victoria.

The triangulation was carried about 90 miles up the island, and furnished more than thirty points, including signals placed on mountain peaks, buildings, church spires, etc., all of which were used in connexion with the topographic mapping, or are available for future extension of it. Permanent marks were left on all points where observations were made, in order that they may be useful in extending this work or to local engineers and surveyors. About 45 miles of levels were run and checked by re-running, thus assuring good elevations and affording numerous points, by which the map work was controlled. More than thirty-five of these are permanently marked for utilization in local engineering and surveying problems. The elevations are dependent upon a bench-mark in Victoria which was referred to mean sea-level by data obtained from the Tidal Survey of the Department of Marine and Fisheries.

The mapping was carried on by what is known as the plane-table method. This combines a graphic triangulation giving many hundred locations, and the running of lines with the plane-table and stadia rod. It requires the topographer to complete the pencil drawing of the map in the field—with the country under survey actually before him—and leaves only the finishing, the inking and lettering, to be done at the end of the season, which necessitates a large field force that is not required in the office. Field maps were drawn at a fractional scale of 1:48,000, about an inch and one-third to a mile, which is slightly larger than the scale of final publication, and topographic features are shown by contours at an interval of 20 feet.

The following men rendered efficient services as assistants: K. G. Chipman, S. C. McLean, G. H. Burbidge, T. B. Williams, Oscar Barrette, T. A. McElhanney, F. S. Falconer, and J. D. Galloway.

Much valuable data was furnished by the Surveyor General of British Columbia, the City Engineer of Victoria, and by the officers of the Militia Department stationed at Victoria.

# TULAMEEN DISTRICT, BRITISH COLUMBIA.

*(Charles Camsell.)*

## INTRODUCTION.

### General Statement.

The greater part of the field season of 1909 was spent in the Tulameen district in southern British Columbia. After a short time spent at Hedley obtaining some supplementary information for the Hedley report, the Tulameen district was reached June 29, and work was carried on there until the beginning of October.

In the summer of 1908 topographical mapping of this district had been begun by Mr. L. Reinecke, and by August of this year the field work had been finished. The completed map will cover an area of about 160 square miles.

The geological work on this area proved to be of exceptional interest from a scientific point of view; while the number and variety of metals, as well as coal, found within its limits, makes it a distinctly important one to the mining industry. For these reasons more time was required to do justice to the district than was at the disposal of the party, and about one-third of it yet remains to be examined.

Efficient aid was rendered in the geological work by the two assistants appointed: W. J. Wright and W. Agassiz. Acknowledgments are also due to many of the prospectors and residents of the district for information, and other assistance given.

### Location and History.

The Tulameen district forms a part of the Similkameen Mining division of British Columbia, and is in the Yale district. The southern border of the sheet mapped is about 30 miles north of the International Boundary line; while the western border is about 19 miles east of the Fraser river, at the town of Yale. The area forms a rectangle, the sides of which are approximately 12 miles, by 13 miles; and it embraces within its limits the gold and platinum placers of Tulameen river and its tributaries; the gold, silver, and copper deposits of Bear, Boulder, and Slate creeks; and the coal basin of Collins gulch and Granite creek.

The history of the district prior to 1885 is obscure. Traces of old placer mining operations, which might be referred to the early gold excitement in the lower Similkameen in the sixties, are said to have been found by the placer miners in 1885 and later. Apart from this, however, the region was known only to the voyageurs of the Hudson's Bay Company, and other travellers, who used the old trail running through the middle of the district from Hope to Nicola.

In 1885 the district first came into prominence by the discovery of placer gold on Granite creek. The discovery is said to have been made by John Chance, a cowboy, who, in August, 1885, while riding up the bed of the creek in search of a lost horse, stooped to get a drink, and saw a nugget of coarse gold glistening on the bed-rock. The fact was soon advertised, but the season was then too far advanced for much work to be done. In the following spring, however, there was a large influx of miners into the region, and the greater part of the productive area on Tulameen river and its tributaries was staked out in mineral claims. The village of Granite Creek, which now has only a score of inhabitants, boasted a population of several hundreds; while Tulameen, 12 miles higher up the river, had twice as many. The high tide of production was reached in the year 1886, when gold to the amount of $193,000 was washed out of the gravels, principally on Granite creek.

Since 1887 the district has gradually been on the wane as far as placer mining is concerned, and at the present time only about a dozen men are actively engaged in this class of mining. Several attempts have been made to operate on a large scale by hydraulicking; but either from lack of experience in the operators, or from some other cause, they were not successful. These attempts have merely served the purpose of discouraging the investment of capital in a region which otherwise offers some good inducements for placer mining either by dredging or hydraulicking.

About the years 1898 and 1899 another class of miners began to enter and overrun the country, in the search for the original sources of the rich gold and platinum placers. High grade gold quartz veins were soon discovered in the Granite Creek basin, and in 1899 the gold copper ores of Boulder creek were staked out. In 1900 the properties on the Bear Creek basin, known as Law's Camp, were located, and in 1901 the copper ores of Independence camp, on the head of Bear creek, were discovered. Since then, in every year, some new mineral claims have been staked in various parts of the district, and some of the prospectors have maintained a continuous search for platinum in the solid rock. This search has not as yet been successful, and it is exceedingly doubtful whether sufficient platinum will ever be found in the rock to make it worth the cost of extraction.

For many years coal has been known to exist on Collins gulch; but the date of its discovery could not be learned. Four years ago the outcropping edges of the same seams were discovered on the North Fork of Granite creek, and on these outcrops a great deal of work has been done.

Little is at present being done in either placer or lode mining, but there is evidence that with the advent of the Victoria, Vancouver, and Eastern railway, the various companies owning properties in the district will commence operations.

*Previous work.*—The Tulameen district, though important, has not had much attention paid to it previous to the work of this year. Dr. G. M. Dawson paid a hurried visit to the district in 1888, and his observations are recorded in the Summary Report for that year.[1] In 1900, Prof. J. F. Kemp spent nearly three months in the district, investigating the geology of the platinum along the Tulameen river.[2] Mr. W. F. Robertson, provincial mineralogist for British Columbia, made certain observations on its ore deposits, based on a trip through the district in 1901.[3] In 1906 and 1908, the writer spent a few days at the close of the season examining certain of the mineral claims which showed the most promise of developing into mines, and a few notes on these are recorded in the Summary Report of the years indicated.[4]

## GENERAL CHARACTER OF THE DISTRICT.

The district undergoing examination has partly the topographical features of the Interior Plateau region and partly those of the more rugged bordering mountain ranges. The east and northeast portions of the region have the lowest average elevation, and in this direction the upper levels slope gradually away to the general level of the central plateau of British Columbia. To the south and west the elevations increase. Although the topography in this direction is not that of a typical mountain range, the vertical relief is much greater, and in a few miles the divide between the Fraser and Columbia River drainage systems is reached. This divide is formed by the northern extension of the Cascade range, locally known as the Hope mountains. Followed southward to the International Boundary line, the Hope mountains broaden and divide into the Hozameen and Skagit ranges, which are separated by the deep

[1] Geol. Surv. Summary Report, Vol. 3, Part I, p. 62 A.

[2] U. S. Geol. Surv., Bull. 193.

[3] Report, Minister of Mines, B.C., 1901.

[4] Geol. Surv. Summary Reports, 1907 and 1908.

north and south valley of Skagit river. Continuing northward these mountains follow the trend of the Fraser river, and gradually decrease in elevation until they die away in the plateau region to the north of Thompson river.

The highest elevations in the district are in the southwest, where Lodestone mountain attains an elevation of about 6,100 feet above sea-level. From this side there is a general slope toward the northeast, where the highest points are almost 1,000 feet lower. Looking over this region toward the east from any one of the higher points, the summits are seen to be gently rounded, and of such a uniform level as to give an almost horizontal sky-line. Little indication is conveyed from this viewpoint, of the deep valleys by which the country is dissected. The lowest point in the map is the Tulameen valley, at the mouth of Granite creek, and the difference in elevation between this and the highest point gives a vertical relief of about 3,800 feet. The higher slopes are as a rule easy, but in the lower levels the hillsides are so steep that zig-zag trails are necessary in ascending them.

The whole area lies within the drainage basin of the Tulameen river. This stream rises in the mountains to the southwest of the area, and flowing easterly through the middle of it, passes out, and about 10 miles beyond joins the Similkameen river at the town of Princeton. These waters then find their way down the Okanagan river, and thence by the Columbia river to the sea. The most important tributaries joining the Tulameen are Granite creek on the south, and Otter creek on the north. Other branches—which are important from the fact that they hold rich gold and platinum placers—are Bear, Slate, Champion, Boulder, and Cedar creeks.

Below the mouth of Otter creek the Tulameen river occupies a broad, U-shaped valley, and has a comparatively easy gradient of about 30 feet to the mile. This type of valley is continued up Otter creek to the north, with a still lower gradient, so much so that several lakes have formed, the most important of which is Otter lake, over 3 miles in length. Above the mouth of Otter creek the broad valley on the Tulameen continues for 3½ miles. Beyond this there is an abrupt change in shape, and an accompanying steepening of the gradient. Here the river occupies a narrow rock-walled cañon cut for several hundred feet into the bed of a much broader valley lying above it. This suggests a very recent uplift, at least post-glacial, of this portion of the district.

All the streams tributary to both the Tulameen river and Otter creek have relatively easy grades in their upper portions, but enter the main valleys either by a series of steep falls or through narrow V-shaped cañons. They are, therefore, hanging valleys. The most typical of these are the valleys of Slate and of Elliot creeks.

Virtually the whole of the area is heavily wooded. Parts of it are park-like in appearance, and similar to the Nicola or Kamloops districts; but only in the higher tracts, above the 6,000 ft. level, is there much open, grassy country.

The climate is considerably more moist than in the country farther east in the Similkameen valley; and while the summer temperature does not rise as high, the winters are much more severe. Except in the Tulameen and Otter valleys, there is no land that is free enough from summer frosts to be entirely suitable for agricultural purposes, and even in these valleys only the hardier vegetables are successfully grown. Apart from the very few persons who have homesteads in these valleys, the whole population is, directly or indirectly, engaged in mining pursuits.

Communication with the outside world is at present maintained by means of a wagon road running through the northern and eastern portions of the district between the Canadian Pacific railway at Nicola and the Great Northern railway at Princeton. Surveys have, however, been made by the Great Northern Railway Company for a line through the district, which, when built, will bring it within a few hours' run of Vancouver.

## GENERAL GEOLOGY.

Owing to the fact that only a portion of the area outlined in the forthcoming topographical map was geologically examined, it is impossible to give a complete table of the different formations that occur within it. The following table, therefore, is provisional, and merely covers the portion of the country examined:—

TABLE OF FORMATIONS.

| | |
|---|---|
| Quaternary | Stream deposits.<br>Glacial deposits. |
| Post-Oligocene | Otter granite.<br>Volcanic rocks. |
| Oligocene | Sandstone, shale, and coal.<br>Volcanic rocks. |
| Pre-Oligocene to post-Triassic | Augite syenite.<br>Pyroxenite.<br>Peridotite.<br>Boulder granite.<br>Eagle granite. |
| Triassic | Volcanic rocks with some argillites and limestones. |

### Triassic.

Stratified rocks, provisionally referred to this age, are the oldest rocks in the district. They still cover a wide area, though considerably diminished by later intrusions of eruptive rocks. North of the Tulameen river they cover the greater part of Bear Creek basin, and pass over the divide eastward toward Otter valley. South of the Tulameen river they are found as a narrow strip in Champion Creek basin, between the Eagle granite and the pyroxenite. They occur again in Slate creek, but east of this are covered by rocks of Oligocene age.

A complete section of these rocks has not yet been worked out, partly because no top or bottom has been found, and partly because they have been so much cut up by later igneous intrusions that a complete section is nowhere visible. The partial section exposed in the cañon of Tulameen river between Champion and Bear creeks, shows at the top some bands of limestone interbedded with hornblende schists succeeded by great thicknesses of volcanic rocks in which some narrow bands of argillite and limestone are intercalated. The volcanic rocks are largely agglomerates and breccias, with andesite and diabase flows, the latter being metamorphosed to chloritic and other schists. The prevailing strike is roughly in a north and south direction, with dips varying from 20° to 90°. The rocks have passed through severe orogenic disturbances, and are traversed by many small quartz veins, some of which are highly mineralized. They are cut by all the intrusive rocks of the region, and by all the dikes.

No fossils were found in the limestones, but in the argillites on Slate creek some plant remains were collected, which, however, are so badly preserved as to render identification impossible.

These rocks are referred to the Triassic, from their lithological similarity to rocks of the Nicola series in the Kamloops district, in which Triassic fossils were found by Dr. Dawson. Their structure is such that they must have been involved in much of the orogenic disturbances of Mesozoic times, and they may possibly be older than Triassic, but are certainly not younger. They represent a long period of volcanic activity, during which they were extruded and flowed over the surface. It is probable that part at least, if not all, of the series was deposited under water, and that the narrow bands of true sediments intercalated with them merely represent short periods of quiescence.

## Pre-Oligocene to Post-Triassic.

During the period between Triassic and Oligocene no fossil-bearing strata were deposited in this area, hence it is presumed that this was a period of continuous erosion. During this time, however, the region was not undisturbed, and its geological history is recorded in the intrusions of several large bodies of igneous rock. The sedimentation and accompanying vulcanism of Triassic times was brought to a close by the Jurassic revolution of the western part of the Cordillera when these rocks were uplifted and considerably disturbed. Immediately following this disturbance, and perhaps in consequence of it, batholithic intrusion began. The relative ages of the intrusions have not yet been all worked out, and, therefore, the positions assigned them in the table of formations are provisional only.

*Eagle Granite.*—This granite occupies the whole of the western border of the area from north to south, and has also been traced some distance to the south of it, so that it has a length of at least 15 miles. To the west, the granite passes outside the limits of the map, but it appears to have an average width of about 5 miles.

The Eagle granite is coarse-grained, gneissic in structure, and very uniform in composition. Its constituents are quartz, white feldspar, and biotite. It is traversed by many small quartz stringers and by coarse pegmatite dikes. The gneissic structure has in general a north and south alignment parallel to the general trend of its longer contacts.

On its eastern border the Eagle granite is in contact with the Triassic stratified rocks. It sends off many apophyses into these, and has effected in them a great deal of contact metamorphism; it is, therefore, clearly post-Triassic in age. Outside the limits of the map, to the southwest, is a belt of Cretaceous rocks with conglomerates at the base which contain boulders of this granite, making the age of its intrusion pre-Cretaceous. It is, therefore, approximately contemporaneous with the intrusion of the Coast Range batholith.

*Boulder Granite.*—The area of this granite has not yet been completely outlined; but enough has been mapped to show that it is an important item in the geology of the area. It is found on the west side of Otter valley, running from Elliot creek down to the Tulameen river, while smaller bodies occur on Otter mountain and on Collins gulch. It is an acid, coarse-grained rock, composed of quartz, light coloured feldspar, and greenish hornblende. It has been much fractured and sheared, and often shows slickensided faces. Many of the fracture planes are filled with white quartz.

The relation of the Boulder granite to most of the other rocks is obscure. It is undoubtedly intrusive into the Triassic volcanic rocks, and on Boulder creek contains inclusions of these. It is not found in contact with the Eagle granite. It appears to be older than the augite syenite, for it is much more fractured and sheared, but contacts between the two are not exposed. The Oligocene rocks of Collins gulch, however, rest directly on the Boulder granite, and are younger than it.

*Pyroxenite.*—This rock is best developed in the region, from Lodestone mountain northward to Grasshopper ridge. It enters the area as a band about 2 miles wide at Lodestone mountain, and running northerly from there to Olivine mountain, splits at that point, and continues on across Tulameen river as two narrow bands enclosing an area of peridotite. Small isolated areas of pyroxenite are found at the forks of Bear creek, and on Henning mountain at the head of Bear creek.

Normally, the pyroxenite is a coarse-grained, black, glistening rock, composed almost entirely of black pyroxene and magnetite. At times the pyroxene is dark green in colour and has some feldspar with it. Near the border of the peridotite, olivine becomes an abundant constituent, and many of the pyroxene crystals are of great size. Hornblende is nearly always present, either as an original mineral or as an alteration of the pyroxene.

In age, the pyroxenite is certainly older than the augite syenite. Its relation to the peridotite, however, is peculiar. Prof. J. F. Kemp, as well as the writer, has found dikes of pyroxenite cutting the peridotite;[1] while the writer had undoubted evidence of a dike of peridotite in pyroxenite. Generally, however, the contact between these two rocks is a transitional one, and it seems likely that they are merely differentiation products from the same magma. Several dikes of pyroxenite were found cutting the Triassic rocks.

*Peridotite.*—The peridotite forms an elongated body, about 3 miles long and a mile wide, extending from the summit of Olivine mountain across Tulameen river to Grasshopper ridge. It is surrounded by pyroxenite on all sides except the north, and there it is covered by drift. A small dike is also found on the northeast side of Lodestone mountain.

The peridotite consists essentially of olivine, with occasional grains of chromite. It is, therefore, the variety dunite. It is dark green in colour, sometimes dense black. It alters readily on the surface to serpentine, and is traversed by a great many small veins of this material. It is very resistant to weathering, and forms one of the highest hills in the district. The outcrop has a typical dun colour, and the rock often weathers in spheroidal shape. It is not found in contact with any other rock except pyroxenite, and this contact, as already described, is generally a transitional one. The relative age, therefore, assigned to the pyroxenite, would apply to the peridotite.

*Augite Syenite.*—This rock has a considerable distribution in the southern portion of the area on the heads of Slate creek, and some of the western branches of Granite creek. How great an area it covers in this direction is not yet known, for it passes outside the limits of the sheet. The part examined indicates that it has the proportions of a stock of very irregular outline. Dikes and small irregular bodies of similar rock are found to the north of the Tulameen river at Otter lake, and in the basin of Bear creek.

The augite syenite shows considerable variation both in composition and texture. The most common phase is a rock of granitic texture, composed of white feldspar and black pyroxene. Black hornblende is a very common constituent, but is, probably, generally of secondary origin. The feldspars are mostly orthoclase. No quartz is present. In structure it is massive, but it has been somewhat sheared in a north and south direction. Along its contact with the older volcanic rocks it shows an incipient schistose structure.

On Granite creek it underlies the Oligocene volcanic rocks, and is undoubtedly older than these. On the other hand it is intrusive into the volcanic rocks, which are referred to Triassic age. Dikes of augite syenite are also found cutting the boulder granite; while the contact with pyroxenite shows inclusions of pyroxenite in the augite syenite.

## Oligocene.

The period of Oligocene sedimentation was inaugurated by a down-warping of the surface, and in the down-warped area volcanic rocks were first extruded. This was followed by a long period of stable conditions, during which true sediments and coal beds were laid down.

Rocks of Oligocene age cover a considerable area in the southeast portion of the district, in the angle between Tulameen river and Granite creek. Small portions of the series are found on the north side of Tulameen river, on both sides of Otter lake. Southward, in the basin of Granite creek, their extent has not been defined. These rocks have been divided into two series: a lower, which is almost wholly volcanic in origin; and an upper, which is sedimentary and coal-bearing.

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[1] Bull. U.S. Geol. Surv., No. 193.

In composition the rocks of the lower series are basaltic, but become more andesitic toward the top. A small band of conglomerate and sandstone is intercalated with them, and outcrops on the northern face of Jackson mountain, also on Blair creek north of Tulameen river. The volcanic rocks are dark coloured and massive toward the base, but very shaly toward the top. They dip at low angles toward the south, and do not appear to have suffered much disturbance.

The upper series of Oligocene rocks is sedimentary, and contains all the Coal Measures. It covers about 8 square miles, and is found in the basin of Collins gulch, and passes over the divide into the Granite Creek slope. The rocks of this series have not yet been thoroughly examined, but are known to consist of sandstones and shales, with beds of coal. The sandstones are sometimes so coarse as to become conglomerates. The finer grained sandstones contain many plant remains. The shales are very thin-bedded, and they also carry a great many plant remains, which have been identified as mostly Oligocene forms. Four different coal horizons have been determined, and there are, possibly, one or two more. These rocks dip at angles varying from 20° to 40°, and generally toward the centre of the area covered by them. In Collins gulch they have been considerably disturbed, but where elsewhere examined they appear to have a regular dip.

A collection of over forty specimens of fossils was made from two localities; one on Collins gulch, and the other on Granite creek. These have been examined by Mr. W. J. Wilson, of the Geological Survey, who has identified six species of plants. These are: *Comptonia diforme, Taxodium distichum miocenum, Sequoia langsdorfii, Sequoia angustifolia, Sequoia heerii*, and *Sequoia brevifolia*. Four out of the six species are restricted to Oligocene rocks, while the other two range from Cretaceous to Miocene.

Therefore, the rocks are Oligocene in age, and correlated with similar coal-bearing rocks at Princeton, Nicola, Kamloops, and other places in the southern interior of British Columbia.

## Post-Oligocene.

*Volcanic Rocks.*—Volcanic rocks which appear to rest unconformably on the fossiliferous Oligocene have a limited distribution on the divide between Granite creek and Collins gulch. They are not of great thickness, and are basaltic in character. They are dense black in colour, and finely crystalline, while in texture they are amygdaloidal, and in structure massive. They have an irregular or conchoidal fracture, and weather to a dull reddish colour. They have not been disturbed, and are quite fresh in appearance, exhibiting a strongly-marked columnar structure.

*Otter Granite.*—A pink granite—which for convenience in differentiating it from earlier granites has been called the Otter granite—is found on the west side of Otter valley, at the northern end of Otter lake. The distribution of this granite has not yet been outlined, but its western contact has been defined for a distance of about 7 miles. It consists of pink and white feldspar, some dark hornblende, and a little glassy quartz. In places the quartz is so sparingly present that the rock almost becomes a syenite. It is quite fresh in appearance, is unsheared, and forms bold outstanding cliffs. Its relation to the post-Oligocene volcanics is unknown, but apophyses from it cut the volcanic rocks which form the lower half of the Oligocene series, so that its age is post-Oligocene.

## Quaternary.

As the whole area under discussion was covered by ice during part, at least, of the Glacial Period, glacial deposits are widespread. These consist of erratics, unassorted boulder clay, and some stratified clays. The boulder clays are the most important. At Slate creek, stream deposits were noticed between beds of boulder clay, which might indicate an interglacial period. Stratified clays on Bear creek,

associated with glacial and later stream deposits, are probably of glacial origin, and due to deposition in a glacial lake formed by the damming of the outlet of this stream to the Tulameen river.

The stream deposits are important from an economic point of view, for in them were found the gold and platinum placers which first brought the country into notice. These deposits are found in the valleys of all the streams. On the Tulameen river a complex series of terraces line the slopes of the valley up to a height of about 400 feet above the present bed of the stream. The terraces are not continuous along the valley, but are merely remnants of older, more extensive stream deposits, which have not been washed away by later river erosion. In certain places, for example, at the mouths of Slate, Cedar, and Champion creeks, they no doubt represent old channels of these streams which have since been abandoned.

### Dikes.

Besides the larger rock bodies above described, there is a great variety of dike rocks. Those identified in the field are rhyolites, granite porphyries, syenite porphyries, andesites, and diabases. The relative ages of these have yet to be determined.

## ECONOMIC GEOLOGY.

Considering the size of the Tulameen district, it is remarkable what a variety of deposits of economic importance are found within its limits. Not all of these deposits, however, have as yet been exploited, or even prospected. The following list contains all those known to have any present or prospective value:—

Gold and platinum placers.
Gold quartz veins.
Copper and gold-copper deposits.
Silver and silver-lead deposits.
Magnetite deposits.
Chromite deposits.
Molybdenite deposits.
Asbestos.
Coal.

### Gold and Platinum Placers.

The placers of the Tulameen district have, up to date, proved to be the most important of its ore deposits. Since 1885 they have been worked more or less continuously, but the output has gradually decreased and is now very small. The most important localities in which payable placers were found are Granite creek and its tributaries, Collins gulch, Cedar, Slate, Bear, and Boulder creeks, and the Tulameen river below the mouth of Champion creek. All of these streams yielded coarse gold, and in nearly all of them platinum was found with the gold. Other minerals found in association with these in the black sands, were native copper and silver glance.

While the largest gold nugget found in the district—said to have been worth \$320—came from the gravels of Bear creek, the greatest amount of coarse gold was taken from Granite creek, where nuggets weighing from 5 to 8 ounces were frequently found. The Tulameen river was the richest in platinum, and the largest nuggets of this came from the portion of the river between Bear and Champion creeks. The proportion of gold to platinum on the different creeks varied. On Granite creek, estimates by some of the early miners give from 2 to 4 parts of gold to 1 of platinum, while on the Tulameen river between Bear and Champion creeks the proportion is given as about 1 to 1.

Platinum nuggets weighing, possibly, half an ounce, are now in the possession of Mr. Cook, of Granite creek. Samples taken last summer from the bed of Granite creek were found to consist of two kinds of grains: one magnetic, the other non-magnetic. The magnetic grains were covered with small adhering particles of magnetite, while the non-magnetic grains were quite clean. All of the grains were pitted with small holes, and some of them had small particles of the country rock still adhering to them. An analysis of nuggets from these placers made by Mr. G. C. Hoffmann,[1] gave 78·43 per cent of platinum for the magnetic portion, and 68·19 per cent for the non-magnetic. The remainder of the sample was made up of iron, copper, and the platinum metals iridium, osmium, palladium, ruthenium, and rhodium.

The source of the gold has not yet been definitely settled, but from its coarseness and angularity it could not have been transported very far; and it is very probable that it was derived from small quartz veins which traverse the volcanic rocks of Triassic age. Prof. Kemp[2] has concluded that the platinum was derived from the peridotite and pyroxenite rocks lying in the basin of Slate creek and crossing the Tulameen river below Champion creek. In the opinion of the writer, no other source is possible.

In testing for platinum in these rocks, Prof. Kemp's best results were obtained from the peridotite, or from pyroxenite dikes in peridotite; and particularly where alteration had taken place to serpentine or where the rock was rich in chromite. No uniformity in the results, however, could be obtained, and often no platinum could be got where it was most expected.

With a view of getting additional information, samples were collected this summer, and were assayed for platinum by Mr. M. F. Conner, of the Mines Branch. One sample of peridotite, rich in chromite, gave 0·02 of an ounce of platinum to the ton of rock. Two samples of magnetite, from the pyroxenite of Olivine mountain, gave nothing. A sheared zone in pyroxenite containing some chalcopyrite, and a coarse pegmatitic dike of pyroxenite cutting pyroxenite, also gave nothing. The results obtained seem to show that of the two rocks, the peridotite is the more frequent host of the platinum, while the pyroxenite when it is distant from any body of peridotite contains none.

The value of the gold in the various creeks is fairly constant; the banks paying $17.80 for it. The gold from Boulder creek always brought a slightly higher price.

The total gold production of the Tulameen district up to 1908—as obtained from the reports of the Minister of Mines for British Columbia—is about $725,000. There is no doubt, however, that much gold was obtained from these creeks of which the British Columbia government got no returns. From the same source it was ascertained that the total value of the platinum produced was about $45,892. These figures convey no idea of the quantity of platinum produced; for the price paid for it in the early days, when the greatest amount was mined, was not more than $3.50 per ounce, and in the first year or two, only 50 cents. Mr. C. F. Law, who has been closely connected with mining operations in the Tulameen district for a number of years, has made an estimate of the total production of platinum from Tulameen river and tributary streams during the last twenty-four years, and he places the amount at about 20,000 ounces. Of this amount more than half is known to have passed through the hands of certain white men in the district, while the remainder is accredited to Chinamen, who of all placer miners have been the most persistent in their mining operations.

The price of platinum in recent years has fluctuated widely. In November, 1909, it stood at $29.50 for refined platinum, and $33.25 for the hard metal. The hard metal is that which is rich in iridium and osmium, these metals being allowed to remain alloyed in the platinum of the ingots. The platinum of the Tulameen district contains a sufficient percentage of both iridium and osmium to allow it to be classed as hard metal, and it, therefore, brings the higher price. Figures bearing on the average per-

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1 Geol. Surv. of Canada, Vol. II, page 5 T.

2 Bull. U.S. Geol. Surv., No. 193.

centages of platinum, iridium, and osmium in the Tulameen product are not yet available for publication.

Although little placer mining is now being carried on, this is not due to the complete exhaustion of all the available ground. In the opinion of some of the best informed miners in the district, a great deal of ground yet remains in the valley of the Tulameen and its tributaries—particularly Granite creek—that would repay working. It is true this ground is what is called deep ground; but the chances of successfully exploiting deep ground are greater than formerly. Only the 3 miles of Granite creek below the mouth of the North Fork have been thoroughly worked; its tributaries above this are yet largely untouched. On Slate creek, also, and on the Tulameen itself, there are deep gravels and bench deposits, which no doubt could be profitably worked; but all of these require both capital, and intelligent, experienced mining.

On the main Granite creek, a short distance above the North Fork, R. A. Lambert has been working for the last three years. He has built a dam across the stream, from which 600 feet of flume carry the water over the creek bed below. Some 15 to 30 feet of the surface gravels from the bed of the stream have been ground-sluiced out to within a few feet of the actual bed-rock. This portion of the creek bed has not been previously worked, on account of the depth of the gravels, but good pay was obtained immediately above and below, and it is expected that this portion also will give reasonable profit. A company called the British Columbia Platinum Company, holding leases on Tulameen river and Slate creek, has been formed for the purpose of recovering the platinum from some of the deeper ground and benches on these streams.

### Gold Quartz Veins.

On the eastern side of Granite creek, and on the divide between it and Ninemile creek, some very rich stringers of gold-bearing quartz cut the green schists. Two at least of these have been worked in a small way, and the gold recovered by crushing and mortaring. The gold, however, was not evenly distributed through the veins, but occurred in bunches; hence the work was not always profitable.

In the lower part of Granite creek and in Tulameen river directly below it, coarse nuggets of gold, found in the gravels, contained a great deal of white quartz, indicating that the gold was derived from quartz veins higher up the stream.

### Copper and Gold Copper Deposits.

Deposits containing these metals are perhaps the most important in the district, and are certainly the most widespread; for the great majority of mineral claims are located on deposits of this nature. Some of these have been described in the Summary Reports for 1906 and 1908, and are here only briefly referred to.

The Independence group, at the head of Bear creek, is one of those previously described as having an ore body lying in a granite porphyry intrusive between the old Triassic schists and the gneissic Eagle granite. The ore body on this and adjacent claims is a replacement deposit of the butte type. Fissures have been formed in the granite porphyry, and the formation of ore has progressed along these fissures, passing outward from them into the country rock. Secondary enrichment by descending solutions, however, has not gone deep, and the ore body is simply the result of uprising solutions carrying sulphides. The sulphides present are chalcopyrite, pyrite, pyrrhotite, blende, and molybdenite with some tetrahedrite and chalcocite. The chalcocite is undoubtedly a secondary mineral formed by enrichment from chalcopyrite. The gangue of the ores is the altered country rock with some quartz and calcite. The surface ore is said to have given assays of about 20 per cent copper, but the ore on which the value of the deposits depends only averages about 3 per cent. There is also a small amount of gold present with the copper. The ore does not contain sufficient calcite to make it self-fluxing, and the combination of minerals is such that it may be difficult to concentrate.

Law's Camp, on the western slope of Bear creek, was also briefly described in the Summary Report for 1906. The camp embraces a number of claims located on the contact of the gneissic Eagle granite and the interbanded limestones and schists. The deposits are gold-copper replacement deposits of moderately deep-seated origin. The ore bodies occur in the limestone bands as lenses, which pinch and swell both vertically and horizontally. The replacing sulphides are pyrite, pyrrhotite, blende, and galena, and the values are in gold, silver, and copper. The limestone bands are generally narrow, and the schists often form the walls. They dip at from 30° to 60° to the west into the granite, and the ore often seeks the hanging-walls. The gangue is limestone which has not been entirely replaced by the sulphides.

There are in Law's Camp certain exceptions to the above class of deposits, in which the ore bodies are of contact metamorphic origin, connected with the granite or some of its apophyses. These are characterized by a development—along with some of the above-mentioned sulphides—of magnetite, and the formation of a gangue of the lime silicates, garnet, and epidote.

Other copper deposits on which work has been done are situated on Rabbit mountain and on the divide between Elliot and Boulder creeks. These are replacement deposits in Triassic schists, and are connected with intrusions of granite or granite porphyry. The sulphides are pyrite and chalcopyrite, which replace certain bands in the bedded rocks.

Other deposits in which the mineralization has been chiefly by chalcopyrite and which occupy shear zones in pyroxenite, occur on the western side of Slate creek and on the slope of Olivine mountain.

### Silver and Silver-lead Deposits.

Dr. Dawson states that in the early placer mining operations in this district, pellets of pure silver glance strung through with gold were found in the washings on Tulameen river somewhere in the vicinity of the mouth of Eagle creek.[1] The occurrence of these suggests the presence of some remarkably rich deposits of silver ore somewhere in the region traversed by the Tulameen river or its tributaries.

In the bed of Champion creek, where dikes of granite are in contact with crystalline limestone, small veinlets of quartz containing pyrite, blende, and tetrahedrite, traverse both the limestone and the granite. From these veinlets, which are only a few inches wide, remarkably high assays in silver are reported to have been obtained. The silver is probably contained in the tetrahedrite in this case.

Argentiferous galena occurs in the replacement deposits of Law's Camp; but probably the most important occurrence of silver is in the galena of Summit Camp, at the head of Tulameen river, about 12 miles by trail beyond the area mapped. These deposits are apparently replacements by galena, blende, and pyrite, of limestones along zones traversed by lines of fissuring. The deposits appear to be of considerable importance, but are handicapped by being located at too great a distance from easy means of transport.

### Magnetite Deposits.

Bordering peridotite on all sides, and extending from the Tulameen river southward to Lodestone mountain, is a large body of pyroxenite, which almost invariably carries a certain proportion of magnetite. At Coutney's cabin on Olivine mountain, on Lodestone mountain, and elsewhere, the magnetite in the pyroxenite increases to such an extent as to greatly affect the compass. It occurs as short irregular veins or large bunches in the pyroxenite, the whole having in general an east and west trend.

[1] Geol. Sur., Canada, Vol. III, p. 62 A.

These magnetite bodies are not connected with any system of fracturing, but are segregations formed, like the chromite in the peridotite, as differentiation products of a cooling magma.

Several claims were staked on the outcrops of these magnetite deposits years ago, but no development work has yet been done nor tests made.

## Chromite Deposits.

Chromite occurs in varying quantities in the peridotite of Olivine mountain. It appears generally along certain east and west zones, where the peridotite has been most readily altered to serpentine, and occurs in short, irregular veins from half an inch to an inch in width, and in irregular masses or bunches in the dark green olivine. It also occurs in small disseminated crystals in the massive peridotite not connected with any fracturing or fissuring. It is doubtless a differentiation product of the peridotite magma in the process of cooling. In the experience of those working on this peridotite area, some of the best assays for platinum have been obtained from peridotite, very rich in chromite. This is in accord with the results obtained by Prof. Kemp in his study of the geology of the platinum.

## Molybdenite Deposits.

Molybdenite is found sparingly, as disseminated crystals in granite porphyry, at Independence Camp on the head of Bear creek. On Champion creek, however, it occurs in considerable quantity, in altered limestone at the contact of gneissic granite. Being associated with garnet and epidote, it is presumably of contact metamorphic origin. It occurs in flakes and grains, associated with pyrite and a little blende in a gangue of reddish garnet, green epidote, and quartz. A few claims have been staked to cover the exposures of molybdenite, but, owing to the form in which it occurs, it is doubtful whether it can be successfully recovered.

## Asbestos.

Numerous veins of asbestos traverse both the peridotite and the pyroxenite in the Tulameen valley. Although many of the small veins in the peridotite contain a good quality of fibre, the larger veins, and particularly those in pyroxenite, were found to be either too brittle or too talcy to be of commercial importance. But, since no systematic prospecting has been done, it is possible that deposits of commercial magnitude may yet be found.

## Coal.

The occurrence of coal in the district was briefly referred to in the Summary Report for 1908. The coal has long been known, and recently an attempt has been made to prospect the basin and find out its extent.

The basin occupies only about 8 square miles of territory, all covered by coal claims. About fourteen claims have been staked and are being held, but only nine of these seem likely to contain coal in workable quantity.

The coal basin is almost circular, and is occupied by sandstones, shales, clays, and coal seams. These rest conformably on volcanic rocks consisting of agglomerates, basalts, and andesites, and are in part covered by more recent volcanic flows. The rocks have been tilted at low angles, and on the outer borders of the basin appear to dip toward the centre. The angles are never more than 45°, and are generally less. Small folds appear on Collins gulch, and in other places minor faults occur; but on the whole the disturbance is probably not great enough to seriously affect the mining of the coal.

The rocks have been determined from their fossils to be Oligocene in age, and in consequence they are correlated with the coal basins of Princeton, Nicola, Kamloops, and with other Tertiary lake basins of the interior of British Columbia.

The whole basin has not been thoroughly examined, hence it is impossible to say how many seams of coal it may contain. Four coal horizons are known, and it is possible that there may be one or two more. Three samples for analysis were taken from the workings on the Granite Creek side of the basin, and one from Collins gulch. The analyses of these are given below. No. 1 is from a seam 6′-6″ wide, taken from an upraise to the east in No. 2 tunnel on the Granite Creek workings. This seam is 17 feet above the floor of the tunnel, and the sample was taken across the face of the seam. No. 2 is from the 5 ft. seam on which No. 2 tunnel is driven, and the sample was taken right across the face. No. 3 is from a seam about 5 feet thick, in No. 4 tunnel, and was taken from the face of the tunnel, which is 168 feet long. No. 4 was taken from the outcrop of a seam of unknown width on Collins gulch. The analyses were made by Mr. F. G. Wait, of the Mines Branch:—

*No. 1*—

| | |
|---|---|
| Moisture | 3·04 |
| Volatile combustible matter | 31·88 |
| Fixed carbon | 51·11 |
| Ash | 13·97 |
| | 100·00 |
| Coke, strong, coherent | 65·08 per cent. |
| Fuel ratio | 1:1·60 |
| Colour of ash, light ash grey. | |

*No. 2*—

| | |
|---|---|
| Moisture | 4·34 |
| Volatile combustible matter | 31·08 |
| Fixed carbon | 48·89 |
| Ash | 15·69 |
| | 100·00 |
| Coke, strong, compact | 64·58 per cent. |
| Fuel ratio | 1:1·57 |
| Colour of ash, ash grey. | |

*No. 3*—

| | |
|---|---|
| Moisture | 2·97 |
| Volatile combustible matter | 31·28 |
| Fixed carbon | 52·49 |
| Ash | 13·26 |
| | 100·00 |
| Coke, strong, compact | 65·75 per cent. |
| Fuel ratio | 1:1·68 |
| Colour of ash, light ash grey. | |

*No. 4*—

| | |
|---|---|
| Moisture | 3·26 |
| Volatile combustible matter | 43·33 |
| Fixed carbon | 49·70 |
| Ash | 3·71 |
| | 100·00 |
| Coke, tender, coherent | 53·41 per cent. |
| Fuel ratio | 1:1·15 |

The analyses of Nos. 1, 2, and 3 indicate a fairly high grade coal—one which ranks as bituminous. They resemble closely analyses of certain Virginia coals; and even compare favourably with some coals from the Pennsylvania coal field. The coals are also somewhat similar to those of the Nicola field. The majority of the coals of the interior of British Columbia, of this age, are sub-bituminous, or even lignitic; but the higher grade of the Tulameen coal is accounted for either by the greater pressure which it has undergone or by the presence of the volcanic rocks immediately overlying it, which by their heat may have driven off a certain percentage of the water.

The ash is high, because the samples were not picked, and in taking a section across the seam, small clay partings may have been included in the samples.

The coke of the three Granite Creek samples is strong and coherent, and has a bright silvery lustre. A test of a larger sample would be advisable; but from the information obtained from these samples it is evident that the coal will coke, and will give a product which no doubt can be used for smelting purposes.

The coal exposed on Granite creek is undoubtedly of better quality than that which outcrops on Collins gulch, though both are in the same basin; and while the latter will be of use for domestic purposes, the former is a better steam coal, and will be in demand by the railways which are projected through that district.

The development work on this coal basin has all been done on a group of claims recently sold to a company called the Columbia Coal and Coke Company, the members of which are: J. T. Johnston, J. E. Grey, D. Donald, W. L. Parrish, and J. W. Bettes. The work has largely been done on the Granite Creek side of the basin, and amounts to almost 1,000 feet of tunnelling and raises, and a large quantity of open-cuts and test pits. On Collins gulch three tunnels of unknown length have been driven, but these are now caving in.

In a hurried reconnaissance to the head of the Tulameen river, an area of Cretaceous rocks was encountered just above the mouth of the South Fork of that stream. These rocks are probably continuous with Cretaceous rocks which appear on the Skagit river and on the International Boundary line between the Roche and Pasayton rivers. Float coal is reported to have been found on the Roche river, and also on the Tulameen where these rocks cross. If this report is true, it is probable that the coal was derived from these Cretaceous rocks; for no other probable coal-bearing strata were found. No coal has, however, yet been found in place.

# BEAVERDELL DISTRICT, WEST FORK OF KETTLE RIVER, BRITISH COLUMBIA.

*(L. Reinecke.)*

## INTRODUCTION.

### General Statement.

The first part of the season—from July 1 to August 25—was spent in finishing the field work for a topographical map of the Tulameen district, in southwestern British Columbia. The party then moved 80 miles to the east, to Beaverdell, on the West Fork of Kettle river. Work commenced here on September 3, and continued until November 12. In this district our time was occupied chiefly in making a topographic map. Rock specimens were collected for microscopic study in the winter, and four days were spent in an examination of the more important mines and prospects.

Messrs. S. I. Wookey, F. H. McCullough, and L. W. Berry—who acted as assistants—did very satisfactory work. Acknowledgments are due the mine owners and residents at Beaverdell for information and assistance.

### Location.

Beaverdell is situated about 25 miles up West Fork, a branch of Kettle river, in southern British Columbia. It is about 45 miles from Midway, on the International Boundary.

The map when completed will include 20 minutes of longitude and 15 of latitude: that is, an area a little over 14 miles east and west, by 17 miles north and south. It extends from the West Fork, including the mouth of Carmi creek, and the junction of Wilkinson and Ferroux creeks (approximate longitude, 119° 9′), eastward to the valley of Kettle river. The southern boundary is south of the mouth of Cranberry creek on the West Fork (latitude, 49° 24′). The northern boundary passes about 2 miles beyond Arlington hill on the West Fork.

Within this area occur the silver-lead ores on Wallace mountain, and the gold-silver deposit at Carmi. In addition, silver and copper prospects have been opened in various parts of the area.

### History.

Claims were first staked on Wallace mountain in 1889. They were allowed to lapse, however, and active prospecting was not begun until 1896. In that year and the following the more important claims on Wallace mountain were located. Between 1896 and 1900, prospecting was carried on all over the district. The Triple Lakes camp, just west of Kettle river, and the Arlington Hill—since practically abandoned—were then located and worked. Development work was begun on the Carmi mine in 1899; and on the Sally group, on Wallace mountain, in 1900. Mining on a small scale has been prosecuted on Wallace mountain from 1900 to the present date. The Sally group, and the Bounty Fraction, Rambler, and Buster properties, are now in active operation. The Carmi mine was worked between 1899 and 1900, and again in 1904. It has been shut down since then.

## GENERAL CHARACTER OF THE DISTRICT.

### Topography.

The area examined lies entirely within the Interior Plateau of British Columbia. The topography indicates a stage of mature erosion, modified by later glacial action. To the north, wide valleys, with gently sloping sides, and broad, low divides, are the rule; while farther south the main streams occupy typical U-shaped, glacial valleys. The hilltops, everywhere, show evidence of glacial erosion. From the valley of the West Fork the country rises gradually westward to the watershed between the Okanagan and Kettle rivers; while to the northwest it is broken by buttes and mesas, which appear to be remnants of a volcanic plateau. The Sawtooth mountains—running north and south—rise abruptly from the valley of Kettle river to the east, and serve to define the boundary of the Interior Plateau in that direction.

The area covered by the map is drained principally by the West Fork of the Kettle and its tributary, Beaver creek; while a strip about 3 miles wide on the eastern edge drains into the main Kettle river. The West Fork and the main Kettle cross the area in slightly converging valleys in a north and south direction. About 6 miles due north of Beaverdell, the West Fork takes a wide sweep to the west and comes back to its original course at that place. Beaver creek, rising near the Kettle river, flows to the south and west and enters a broad north and south valley about 4 miles above its junction with the West Fork at Beaverdell.

Within the area covered by the map sheet, the gradient of the main valley bottoms is fairly uniform, perhaps 25 to 40 feet to the mile. Within this area the Kettle river has the steep sides and flat bottom of a glacial valley. This is also true of the West Fork as far as Beaverdell, and for 4 miles up Beaver creek. East of Beaverdell, Wallace mountain rises abruptly to a height of about 2,000 feet above the valley bottom. Between the mountain and the valley of the main river, the country is rolling, with but few prominent points. Goat mountain—which is the highest point between the West Fork and Kettle rivers—though showing up in bold relief from the east, is not very much higher than the flat-topped hills to the west and northwest.

North of the transverse valley of Beaver creek the topography is flatter, and the elevation gradually decreases toward the north and east. An area of marked relief occurs in the northwest corner of the region, where Red mountain and The Nipple form two prominent points overlooking the country to the south and east. Goat mountain, Red mountain, and The Nipple, are nearly of the same elevation, perhaps 6,000 feet above sea-level; or about 3,500 feet above the lowest point in this part of the valley of Kettle river.

### Climate and Agriculture.

The climate resembles that of other upland portions of the Interior Plateau, though it is perhaps drier than the western edge of that region. The summers are cooler than in the lower lying valleys to the south, and the winters are not so cold.

Little land has been cultivated, hay, and vegetables being the only agricultural produce. Fruit growing is still in the experimental stage, though it is understood that it has been successfully begun at Rock Creek, 35 miles down the valley.

### Timber.

The country is well timbered; bull or yellow pine (*Pinus ponderosa*) grows in the lower valleys and on the more open hillsides, while tamarack (*Larix occidentalis*). and fir (*Pseudotsuga mucronata*) are more often found on the hills. There is enough large pine, tamarack, and fir left for extensive lumbering operations.

### Transportation.

The district is connected by a good wagon road, which follows Kettle river and West Fork through Beaverdell to Carmi, with the Canadian Pacific and Great Northern railways at Midway. One branch of the road runs up the main Kettle to a point almost directly east of Beaverdell. A switchback road, with a remarkably low gradient, connects Beaverdell with the Sally and Bounty Fraction mining properties on Wallace mountain. There are a number of good trails on the mountain and up the main valleys, but pack trails over the remainder of the area are few and poor.

## GENERAL GEOLOGY.

A large part of the area was not visited, and the following geological notes are based upon the examination of specimens collected and exposures seen in the course of preliminary topographical work. No attempt, will, therefore, be made to distinguish formations, to correlate them, or to define their areal boundaries.

Fine-grained aplites, in places cut by andesite and quartz porphyry dikes, occur east and south of Triple Lake valley. Andesite outcrops extensively along the Kettle river south of Canyon City; while older volcanics are found in the river bed north of that place.

Various plutonic types, such as granite, granodiorite, diorite, and monzonite, outcrop on the hills on both sides of the West Fork, also extensively along the east side of Kettle river. A large body of andesite occurs along the eastern side of the West Fork near the mouth of China creek. Basalts, andesites, breccias, and tuffs occur on the higher points near Goat mountain, and in the northwestern corner of the area.

## ECONOMIC GEOLOGY.

The more important mineral deposits of the district are the silver-lead ores of Wallace mountain and the gold-silver occurrence at Carmi. Good values in silver have been found at many places along the West Fork valley. A good deal of prospecting has been done near the Triple lakes, on Arlington hill, and in the country between the West Fork and Beaver creek; and ores carrying fair values in copper, silver, and gold have been opened up in several places.

### Wallace Mountain.

The silver ores of Wallace mountain occur in a series of fissure veins in granite. The ores consist of galena, with argentite, sphalerite, ruby silver, and tetrahedrite. These are associated with quartz, pyrite, and in rare cases arsenopyrite. Native silver occurs near or in certain fault planes, and silver chlorides are sometimes encountered near the surface.

#### OCCURRENCE AND STRUCTURE OF VEINS.

The veins vary in width from a thin stringer to perhaps 10 feet. They strike east and west, and dip south, at angles varying from 45° to almost 90°. A dip to the north has been noted, but may in this case be due to local displacement.

The vein matter consists of silicified and altered granite, accompanied by one or more bands of quartz. There is, generally, a sharp break between the composite vein material and the fresh granite, forming a well-defined foot and hanging-wall. The relative proportion of quartz and altered granite varies greatly; the stringers of quartz are generally found near the hanging and foot-wall.

The heavy stringers of quartz, and occasional regular banding of the sulphides, suggest that part of the vein was formed by fissure filling. The granite within the veins shows evidence of crushing. Quartz fills the spaces between the fragments, and

quartz and sulphides can be seen replacing the original minerals of the granite. Replacement of the country rock in the walls is not very evident in the hand specimens, and the sulphides appear to be absent; it seems probable, however, that microscopic study will show some replacement of the country rock to have taken place at least close to the vein.

In some instances the ore occurs in or near dikes of dense, fine-grained aplite. These are from 3 to 8 feet wide, and strike east and west.

### POST-MINERAL FAULTING.

The veins are cut by a series of fault planes with a north and south strike, and a dip to the west of from 35° to nearly 90°. Instances of a northeast-southwest strike are said to occur. The displacement, which varies from 1 foot to over 300 feet, is toward the south, when following the lead from west to east. There are one or two exceptions to this rule, but the displacement in such cases is not very great. There appear to be two series of north and south faults. In the Rob Roy No. 7 tunnel of the Sally group a fault plane with a dip of 80° cuts one dipping 35°. There appears to have been an upward movement on the western side of the steeper fault, with a displacement of over 300 feet.

Along the fault planes between the broken ends of the veins there is usually a thin band of gouge—kaolinized vein material, and partly decomposed ore. Thin plates of native silver and calcite are usually found in or near these fault planes.

### OXIDATION.

There is little evidence of the oxidation of the vein material by surface waters. In some of the mines of the Sally group, oxidized ore has been found to a depth of 75 feet, but in general the fresh sulphides are encountered quite close to the surface. The leached vein matter or gossan has doubtlessly been removed by glacial scouring.

### ORE VALUES.

On account of the small amount of underground development, it is not possible to determine variations in the character or values of the ore relative to depth from the surface. Values vary greatly in a lateral direction: bunches of ore which after sorting by hand averaged $200 to the ton, have been taken from leads which in other places proved almost barren. The occurrence of pay ore along a lead is, however, fairly constant. As an instance, the Sally mines—with 2,000 feet of tunnelling—have shipped nearly 700 tons of ore averaging over $100 to the ton, and have about 4,000 tons on the dump averaging perhaps $25 per ton. This was done with very little auxiliary stoping.

### DISTRIBUTION.

The boundaries of the area containing the silver-bearing deposits have not been definitely determined. Properties of the shipping class lie within an area of about 3 square miles on the western and southern slopes of Wallace mountain. The Sally mines are 3 miles by wagon road from Beaverdell, and 1,500 feet above the town; while the properties on the far side of Dry creek are about 2½ miles farther east.

### MINING DEVELOPMENT AND PRODUCTION.

On the western slope of the mountain the ore has been worked by tunnels driven along the veins; while in other parts of the area shafts have been sunk from 40 to 100 feet deep, and the ore taken out by drifting and stoping.

The ore shipped from three of the properties totals 925 tons, valued at about $98,500. Of this, the Sally group produced $73,000; the Bounty Fraction and

Duncan, close to $16,000; and the Rambler, a little over $9,500. These returns were furnished by the managers or owners of the mines. Ore has also been shipped from the Bell claim.

A serious hindrance to the development of the camp is the excessive cost of transportation. The cost of freighting from the mines to Trail, with smelter charges, amounts to from $30 to $35 per ton; the freight charges to Midway alone are $16 per ton. On this account, ore averaging less than $100 per ton cannot be handled with any great profit. Railway connexions to Beaverdell, and a concentrator to eliminate the slow and expensive hand-sorting of the ore, would greatly facilitate the opening up of the silver deposits.

## The Carmi Mine.

This gold and silver bearing deposit is situated southwest of the now abandoned town of Carmi, 5 miles above Beaverdell. The mine has been abandoned for some time, and the shaft is filled with water. The following notes were made from what could be seen on the ore dump and surface outcrops.

### ORES AND THEIR OCCURRENCE.

The ores consist of zinc blende, chalcopyrite, pyrite (probably gold-bearing), and galena in a gangue of quartz, and ferruginous dolomite. A small amount of molybdenite is also present.

The ore occurs in a vein from 2 to 4 feet wide, with an east and west strike, and a dip to the south of about 45°. The country rock is a gneissic granite of the same character as that on Wallace mountain. The vein filling consists partly of quartz and partly of a dense, compact rock of the same appearance and texture as the dikes on Wallace mountain. The proportion of quartz varies along the vein. Ore is found in both quartz and the compact vein filling mentioned above.

### MINING DEVELOPMENT AND PRODUCTION.

A shaft 183 feet deep has been sunk on the western end of the property, and 200 feet of drifting done from it. There is also a tunnel 86 feet long, and another shaft 40 feet deep. A mill with a ten stamp battery was erected in 1904, and 400 tons of waste treated with amalgam plates and by the cyanide process.

Between 1899 and 1900, nearly 900 tons—averaging $26 per ton in gold and silver—were shipped to the smelter at Greenwood.

# A RECONNAISSANCE ON THE UPPER FRASER RIVER BETWEEN FORT GEORGE AND TÊTE JAUNE CACHE.

*(G. S. Malloch.)*

## INTRODUCTION.

The main line of the Grand Trunk Pacific railway, now under construction, crosses the Rocky mountains by the Yellowhead pass, and descends to the Fraser river, which it follows for 300 miles to Fort George, at the mouth of the Nechako. This part of the route follows the line surveyed in 1876 by the Canadian Pacific Company for their main line, but abandoned in favour of that by the Kicking Horse pass. Their survey of the Yellowhead route was begun in 1871, and in that year, also, Dr. A. R. C. Selwyn began the work of the Geological Survey in British Columbia. He received instructions to extend his explorations to the Yellowhead pass if time should permit. Owing to the lateness of the season, he did not reach the pass; but, after ascending the North Thompson and crossing to the Fraser, at Tête Jaune Cache, he followed the river up to within 20 miles of his objective point.[1] In 1898, Mr. James McEvoy made an exploratory survey of the old Canadian Pacific Railway route between Edmonton and Tête Jaune Cache, an account of which is published in the Annual Report for that year.[2] From Tête Jaune Cache, however, to the vicinity of Fort George—which was visited by Dr. Selwyn and Dr. G. M. Dawson in 1875, and by the latter again in 1876[3]—no geological examination had been made of the Fraser by members of the Geological Survey until the summer of 1909, when the writer was instructed to undertake the work. He was assisted by A. C. T. Sheppard, and P. A. Fetterly. The Fraser river was ascended from Fort George in canoes, and, on the return journey from Tête Jaune Cache, a traverse of it was made with micrometer and plane-table. The distance between these points is nearly 315 miles. The journey up river occupied twenty-one days, while twenty-six days were spent in traversing.

The geological examination was necessarily a hurried one, and the scarcity of exposures on the river banks added to the difficulty of studying the different formations. Twelve days were spent in climbing and exploring the mountains flanking the valley, but although almost continuous exposures were seen on them, especially in the gullies of streams descending their slopes, the strata were invariably so crumpled and faulted that nowhere was an opportunity afforded for measuring a satisfactory section. It is believed, however, that had time permitted, much more detailed information could have been gathered by camping near timber line on the different mountain ridges and traversing their crests.

## GENERAL CHARACTER OF DISTRICT.

### Topography.

Topographically, the portion of the Fraser valley examined falls into two main divisions. From Tête Jaune Cache down to the Grand cañon—100 miles above Fort George—it runs between two parallel ranges of mountains, while for the remainder

1 G.S.C. Report of Progress for 1871-2, pp. 16-72.

2 G.S.C. Annual Report, New Series, Vol. XI, 1898, Part D.

3 G.S.C. Report of Progress, 1875-6, pp. 28-83, and pp. 233-265; and Report of Progress for 1876-7, pp. 17-94.

of the distance it traverses the Interior Plateau, where the hills are irregularly distributed, and usually cannot be seen from the river. The trough which the Fraser occupies in the first of these topographic divisions is one of the striking features of the mountainous region of eastern British Columbia. It extends from the International Boundary northwest for 800 miles, and in origin is evidently quite independent of the present drainage system; for in it the Kootenay, Canoe, and Findlay rivers flow southeast, and the Columbia, Fraser, and Parsnip, northwest. Moreover, the trough, at the divides between the different drainage systems, is as wide and has as gentle a slope as where it is occupied by any of the large rivers mentioned. This is well exemplified at Tête Jaune Cache, where the Fraser enters the trough from the east and where, although the part below the elbow is drained by a small tributary only, carrying about one-tenth of the amount of water in the main river, the trough is not contracted nor the gradient changed.

On the other hand, the lateral tributaries of the Fraser break through narrow gaps in the side walls of the trough and have steep gradients until they reach the strip of flat land which lies along the river. This strip is from 3 to 5 miles wide, while the distance across the trough from peak to peak averages about 10. The ranges flanking the trough are lower than the succeeding ones, and decrease in height from Tête Jaune Cache to their northern ends near the Grand cañon. At the former place they rise 7,000 feet above the valley, while near the latter they are not much more than 4,000 feet above it. There is, however, a break in this general decrease in height. The range on the northeast side at a point opposite the mouth of Goat river, and the range on the southwest side at a point below the gap of Dome creek, suddenly increase in elevation. From these points the ranges become lower, but the rate of decrease is much more rapid on the southwest side, so that the range there ends above the Grand cañon; whereas the range on the other side extends to Toneyquah creek. From the river a few glimpses were caught of a long range extending northwest from near the mouth of Big Salmon river; this is, doubtless, the continuation of one of the walls of the trough beyond the wide break through which the Fraser escapes from it. The continuation of the trough in that direction is described by Mr. R. G. McConnell.[1]

The Fraser pursues a most tortuous course in the strip of flat land in the centre of the trough, swinging from side to side in broad, sweeping curves, and sometimes approaching within short distances of the enclosing ranges. In many cases very narrow necks are all that remain to separate a higher from a lower bend, and numerous 'oxbow' lakes along the course of the river bear witness to the frequency with which similar necks have been cut through in the past. The tortuous course of the river is due to the excessive load of sediment which it carries, and not to a low gradient. The sediment consists largely of flakes of mica and rock flour produced by the grinding of large glaciers on the micaceous schists and gneisses, of which the mountains are chiefly composed. Glaciers are comparatively rare on the side walls of the trough, but are common in the higher ranges on either side of them. The Fraser is not particularly turbid at Tête Jaune Cache, but several of its tributaries, especially Sand creek and Rau Shuswap river, are heavily loaded with silts. The latter is the largest tributary the Fraser receives in this part of its course, and drains a high, mountainous country, in whch many large glaciers were seen. On the other hand, many of the smaller tributaries are clear, except after heavy rains. Many of them do not head in glaciers, or else have lakes on their courses which act as catchment basins for sediment derived from glaciers.

As has been stated, the country through which the Fraser flows from the Grand cañon to Fort George, belongs to a second topographic type known as the Interior Plateau, and differs from the first in the absence of regular mountain ranges. It is

[1] G.S.C., Annual Report, Vol. VII, 1894, pp. 18-19 C.

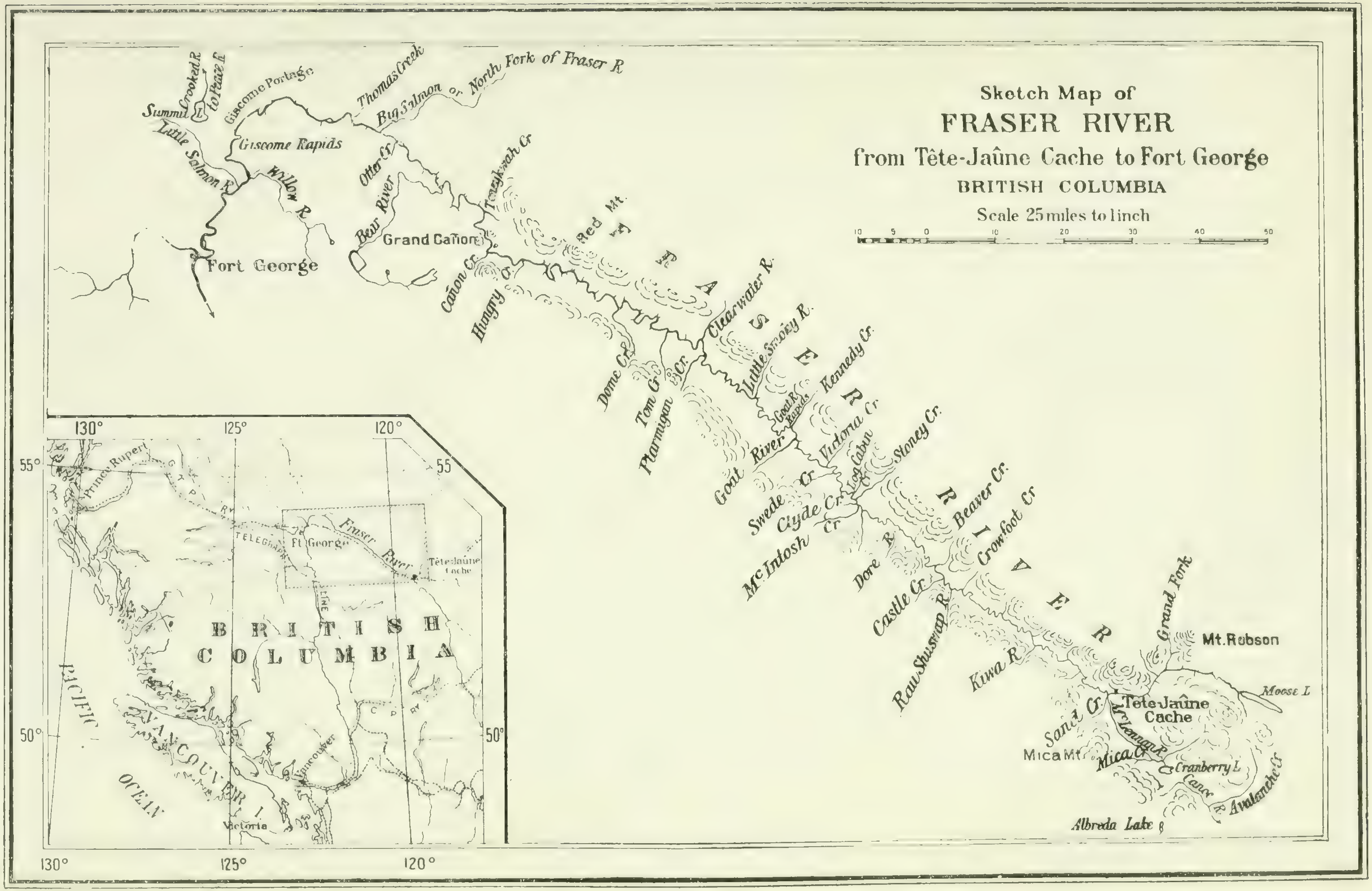
Sketch Map of
FRASER RIVER
from Tête-Jaûne Cache to Fort George
BRITISH COLUMBIA
Scale 25 miles to 1 inch
10 5 0 10 20 30 40 50
FRASER RIVER
Fort George
Little Salmon R.
Summit L.
Crooked R.
to Peace R.
Giscome Portage
Giscome Rapids
Willow R.
Thomas Creek
Big Salmon or North Fork of Fraser R.
Otter Cr.
Bear River
Grand Cañon
Tsaykwah Cr.
Cañon Cr.
Hungry Cr.
Red Mt.
Dome Cr.
Tom Cr.
Ptarmigan Cr.
Clearwater R.
Little Smoky R.
Goat River
Goat R. Rapids
Kennedy Cr.
Victoria Cr.
Log Cabin Cr.
Stoney Cr.
Swede Cr.
Clyde Cr.
McIntosh Cr.
Dore R.
Beaver Cr.
Crowfoot Cr.
Castle Cr.
Raw Shuswap R.
Kiwa R.
Grand Fork
Mt. Robson
Moose L.
Tête Jaûne Cache
Sand Cr.
McLennan R.
Mica Mt.
Mica Cr.
Cranberry L.
Canoe R.
Avalanche Cr.
Albreda Lake
130° 125° 120°
55° 50°
Prince Rupert
G. T. P. RY.
TELEGRAPH
Ft George
Fraser River
Tête Jaûne Cache
LINE
BRITISH COLUMBIA
C. P. RY.
Vancouver
VANCOUVER I.
Victoria
PACIFIC OCEAN

Fig. 1.

characterized by extensive upland areas intersected by an irregular system of comparatively broad valleys. Numerous lakes occur both in the uplands and in the upper reaches of the valleys, and the streams are clear and become quite warm in summer.

### Climate and Agriculture.

The rainfall is heavy throughout the district, particularly in the country in the vicinity of the Grand cañon, where the prevailing westerly winds, deflected by the ends of the ranges bordering the river, are forced to ascend. Here, the rainfall is excessive, and it is doubtful whether grain crops could be successfully ripened. The temperature in summer is very equable, and in the valley white frosts are rare before October. The area of farming land about Fort George is very large, and the soil excellent. Westward along the Fraser, it is rather light, owing to the large quantity of mica in the river silts.

### Fauna and Flora.

The region abounds in wild game of various kinds, especially between Little Smoky and Rau Shuswap rivers. Near Fort George and Tête Jaune Cache, the quantity of game is kept down by the Indians, who have their headquarters there. Black bear and moose are particularly numerous, and it is almost impossible to land on any of the bars along the river without seeing tracks of both. Beaver are numerous, and may often be seen swimming in the river in broad daylight; while nearly every aspen near the water has been cut by them and many of their dams obstruct the smaller tributary streams. One herd of wapiti was seen, near the timber line. Numerous trails, beaten deep into the higher slopes, bear witness to the large number of goats which winter there but doubtless summer on the higher ranges on either side. Grizzly and cinnamon bears are reported to be common, but none were seen. The smaller fur-bearing animals are numerous. Rainbow and silver trout, and whitefish are plentiful in the Fraser and many of its tributaries. Salmon ascend the river to Tête Jaune Cache, where they are speared in large numbers while crossing shallow bars; the run was at its height there about August 25.

The timber of the district is large, and grows thickly; the heavy rainfall in the central portion of the district traversed has protected it from fire, though large areas near Fort George and Tête Jaune Cache have been destroyed. Spruce, both black and white, is the principal tree, ranging from the timber line to the river bottoms. Along the latter, balsam, white birch, and, in the more sandy parts, cottonwood, are nearly as common. Cedar, in most cases, is confined to the lower slopes of the mountains, but also occurs near the river wherever the banks are rocky and the drainage good. Some of them reach a large size; specimens 12 feet in diameter being seen. Above the belt of cedar there is usually one of hemlock, and above that, spruce and balsam to the timber line. No larch was seen nor pine, except Banksian pine, which, with the aspen poplar, is common in the drier parts about Fort George and Tête Jaune Cache. Douglas fir also occurs along the river terraces at the latter point, and some fine tracts of it were seen in the vicinity of Fort George. All kinds of wild berries abound, and are picked by the Indians and dried on leaves for use during the winter. Underbrush is very thick, except in the regions recently burnt over, and the alders along the river and the stream often attain diameters of 8 inches, and grow so thickly in places that it is almost impossible to force one's way through them. They also extend for a considerable distance up the slopes of the mountains. The 'devil's club' is also present in unwelcome abundance wherever the ground is damp and sufficiently shaded to protect it from the sunlight.

### Transportation and Communication.

Fort George is reached from Ashcroft by a stage line to Soda creek, and from there by steamer. In seasons of high water a transfer is usually made from one

steamer to another at Fort George cañon, 15 miles below the Fort. The steamers being of light draught, and having powerful engines, might be able to ascend the river to Tête Jaune Cache, though the Grand cañon would be difficult to pass and might prove to be altogether impassable, at high water. Tête Jaune Cache can be reached by pack train from Edmonton across the Yellowhead pass, or from Kamloops, by ascending the North Thompson. There is a waterway, also, up the Columbia from Revelstoke, or down from Golden to the mouth of Canoe river, then up the latter almost to its head, where a short portage leads to Cranberry lake, which drains to the Fraser by McLennan river. This route should only be attempted by expert canoemen.

## Commercial Possibilities.

The building of the Grand Trunk Pacific will make the timber in the Fraser valley valuable; for the low cost of hauling it over the easy grades of the Yellowhead pass will, doubtless, enable it to compete successfully with the inferior timber growing on the eastern slopes of the Rockies.

## GENERAL GEOLOGY.

As already stated, the geological examination was much too hurried to permit more than an examination of the outcrops on the river banks, and, in a few places, on the bordering hills and mountains. These data are insufficient to afford a complete geological section in a region where the rocks have been folded, faulted, crumpled, and greatly metamorphosed; and where there is a marked scarcity of fossil evidence. The district lies between two areas in which the geology has already been worked out in some detail, but except in a very general way the formations of the two districts have never been correlated. The first of these areas is the Rocky Mountain region, in which a section was measured by Mr. R. G. McConnell[1] along the main line of the Canadian Pacific railway. This section was found by Mr. J. C. McEvoy[2] to correspond closely to that exposed in the country immediately east of the district examined during 1909, and in which, on the whole, the same parallelism holds true. The second area is the Interior Plateau of British Columbia, which has been described in numerous reports by Dr. G. M. Dawson[3]; while the Cariboo Mining district, lying a comparatively short distance southeast of Fort George, was examined by Amos Bowman.[4]

### TABLE OF FORMATIONS.

| | |
|---|---|
| River drift.. .. .. .. .. .. .. .. .. .. .. | Recent. |
| Glacial drift.. .. .. .. .. .. .. .. .. .. .. ('a' from west; 'b' from east.) | Quaternary. |
| Lignite Tertiary?.. .. .. .. .. .. .. .. .. | Miocene. |
| Quesnel River series?.. .. .. .. .. .. | Cretaceous? |
| Banff series.. .. .. .. .. .. .. .. .. .. .. | Carboniferous and Devonian. |
| Castle Mountain series.. .. .. .. .. .. | Upper Cambrian. |
| Bow River series.. .. .. .. .. .. .. .. | Lower Cambrian. |
| Shuswap group?.. .. .. .. .. .. .. .. | Pre-Cambrian? |

*Shuswap Group.*—A series of mica schists, garnetiferous schists, and gneisses, occurring in the mountain range bordering the trough on the southwest, has been referred to the Shuswap group by Mr. McEvoy. These rocks form the upper part of the range from opposite Tête Jaune Cache to the gap of the Rau Shuswap river. Mr.

[1] G.S.C., Annual Report, 1886, Part D.

[2] G.S.C., Annual Report, Vol XI, Part D.

[3] See especially G.S.C. Annual Report, Vol. VII, Part B.

[4] G.S.C., Annual Report, 1887, Part C.

McEvoy[1] states that some of the finer grained gneisses are certainly intrusive. Mica mountain, where Mr. McEvoy got his specimens. was not visited; and elsewhere no rocks were seen by the writer from which this conclusion could be verified either from a study of hand specimens or from the field relations, and the author is disposed to regard the schists and gneisses as metamorphosed sediments. They dip to the southwest at comparatively high angles, and overlie beds of garnetiferous schists, some of which contain large crystals of staurolite. These in turn overlie beds of impure crystalline limestone, resting on mica schists, the sedimentary origin of which is revealed by weathered surfaces where rounded grains of quartz can be detected. A similar section was seen at other points on the same side of the trough, and the author suggests as an alternative hypothesis that, the schists and gneisses are the metamorphosed equivalents of the grey quartzites which occur in the Castle Mountain series; while the trough may have been eroded along the outcrop of the soft calc schists at the base of the formation. In a region where faults are numerous the evidence to support this hypothesis is far from being conclusive. The gneisses are cut by large dikes of pegmatite holding crystals of muscovite, some of which measure over 20 inches across.

*Bow River Series.*—The Bow River series consists of a succession of fissile micaceous and graphitic schists, dark coloured limestones, and a peculiar conglomerate containing rounded pebbles of quartz and comparatively fresh feldspar, with numerous flakes of sericite, which, in some cases, give the rock a certain amount of schistosity. One of the quartz pebbles measured 6 inches in diameter. In some places the conglomerate contains fragments of the dark coloured limestone with which it is interbedded. Many quartz veins, holding flakes of sericite and crystals of siderite, have been developed in this formation.

This series forms the range bordering the trough on the northeast from Tête Jaune Cache to the high mountain opposite the mouth of Goat river. The general dip is southwest, as is the case in the range opposite, but the beds have been thrown into a number of crumples. To the east, however, an anticline occurs, and the beds of this formation were seen to dip under the limestones, dolomites, and quartzites of the Castle Mountain series, which form the mass of Mount Robson and other high mountains in that direction.

*Castle Mountain Series.*—The beds belonging to the Castle Mountain series were not examined closely, and the line between them and the succeeding Banff series was not made out. In McConnell's section[2] they are described as being composed of a succession of massive dolomites and limestones, with calc schists and argillites; but McEvoy mentions[3] the occurrence, also, of thick beds of grey quartzite. Beginning on the mountain opposite Goat river, this formation crosses the river at the foot of Goat River rapids, where talcose and chloritic schists and quartzites were seen. Similar rocks were found on the hills above the gap of Tom creek on the opposite side of the trough, and if the suggestion as to the age of the Shuswap gneisses is correct, it might be possible to trace the progress of the metamorphic action, by which it is supposed they were produced from the grey quartzites. The gneisses were last seen a little above the gap of Rau Shuswap river.

*Banff Series.*—As stated above, the Banff series could not be definitely separated from the preceding series, nor could the position of the different beds relative to one another be made out. This was due to the want of continuous exposures and to the amount of crumpling and faulting which the beds have suffered. The predominating beds are massive limestone, and are usually coarsely crystalline and fairly pure.

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[1] G.S.C., Annual Report, Vol. XI, Part D, p. 38.
[2] G.S.C., Annual Report, 1886, Part D, pp. 24-29.
[3] G.S.C., Annual Report, Vol. XI, Part D, p. 32.

Beds of brownish-yellow shale overlie large thicknesses of limestone on both sides of the trough, and may be the highest beds represented. At the Grand cañon a section was measured which showed thick limestone beds overlying dolomites, micaceous shales, and quartzites. Some of the latter are banded in red and greenish layers, the colours being imparted by quartz pebbles, some of which are as large as peas. Some pebbles of black chert also occur in them. Above the limestone were seen talcose schists and black carbonaceous shales, and above these, more limestone. Two varieties of corals were found on the slope of Red mountain, which Mr. L. M. Lambe believes to be of upper Devonian age; but, unfortunately, they came from beds separated by a crumple, and the sequence of beds observed here was not duplicated at any other point examined. It is evident, however, that they do not represent the top of the series.

Besides forming the ends of the ranges bordering the trough, this formation forms an irregular line of hills across the valley through which the river has cut the Grand cañon. The last exposures of the limestone occur in the river a little below Thomas creek, where they dip to the west and evidently pass below younger strata.

*Quesnel River Series.*—Greenish schists, grey sandstones, and a heavy bed of conglomerate containing pebbles of quartzite and of badly decomposed volcanic rocks, are referred to the Quesnel River series,[1] doubtfully, for it is possible that they represent the base of the Tertiary. However, the degree of metamorphism the schists have undergone, and the comparatively high angles at which some of the beds dip, favour the view that they belong to the Cretaceous. They outcrop on both sides of Giscome rapids; the conglomerate, the last seen, disappearing a little below the mouth of Little Salmon river.

*Lignite Tertiary.*—No exposures of rock were seen for 25 miles above Fort George, but there is an exposure of the Lignite Tertiary a short distance below the Fort; and Dr. Dawson supposed[2] that the measures underlie much of the country. A small, isolated exposure of these beds was seen on the east bank near the head of the Giscome rapids.

*Glacial Drift.*—The whole region has been glaciated, and boulder clay occurs at different points along the river. These deposits were formed by two sets of glaciers; the first of which descended into the Interior Plateau from the mountains to the east, and the second from those to the west. The drift of the latter is characterized by the presence of granite fragments from the Coast range, and volcanic rocks from the western part of the plateau. On the other hand, that from the east contains fragments of older rocks, and it alone is seen on the river from Tête Jaune Cache to Giscome rapids, where it is overcapped by the drift from the west. A band of gravel separates the two boulder clays, and doubtless represents an outwash formed when the second glacier was advancing. The rapids seem to be due to accumulations of boulders washed from the boulder clay through which the river has cut its channel. The Goat River rapids, higher up, are also due to thick accumulations of boulder clay, probably deposited during a temporary halt in the retreat of the glacier from the east. An esker, composed of sand and gravel, and about 300 feet high, occurs at the foot of the rapids.

*River Drift.*—Great thicknesses of river drift are exposed at different points along the Fraser. Where it is exposed to the bottom, the river drift is usually found to rest on boulder clay, but sometimes on bed-rock. The drift consists of clays, sand, gravel, and beds of peat. As one would expect, the clays are found generally on the banks along parts of the river where the current is comparatively slow; while the

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1 G.S.C., Annual Report, 1887, Part C, pp. 17-19.

2 G.S.C., Report of Progress for 1875-6, pp. 256-257.

thickest deposits of sand occur below the different rapids. In many cases, however, layers of sand and clay alternate, and when this is so, many landslips have taken place from the cut banks. These are easily recognized by the discordance in dip of the different layers and by the overturning of trees. Some of the slips extend back for some distance from the river; in one case an angle of only 18° was measured from the foot of one of these slides to the top of the bank from which it had come. Many of the clays have been hardened to some extent by calcareous cements.

The beds of peat seem to have been formed in two ways: many of the smaller and more irregular beds have been formed by accumulations of water-logged drift wood in the shallow water at the edges of the river, which were afterwards covered by deposits of silt; while others are too pure to have had such an origin, and probably represent vegetable matter which decayed where it grew, and was afterwards buried by river deposits. In many cases the river would be forced to build up a portion of its bed when its course was checked lower down by the growth of fans of tributary streams, and this may have occurred several times, so that more than one deposit of peat might be buried. In one cut bank two regular seams of peat, each over 12 inches thick, were seen.

The fans of the tributary streams consist largely of gravel, and their occurrence at all the stream mouths emphasizes the difference between the gradients of their valleys and that of the bottom of the trough. At the bottom of the river drift there is usually a bed of gravel, which is stained to different shades of red and yellow, and often cemented to a conglomerate by iron rust.

## ECONOMIC GEOLOGY.

With the exception of a mica-bearing pegmatite dike southwest of Tête Jaune Cache, and some small crystals of zinc blende picked up on the mountain north of Tête Jaune Cache, and a piece of float in Tom creek which contained a small quantity of chalcopyrite, no evidence of mineralization in the district was seen except in the sericite- and siderite-bearing quartz veins in the Bow River series. These are very common, and evidently carry some gold, but it does not seem to be present in paying quantities.

### Beaver River Gold Claims.

The district has been very thoroughly prospected; but so far as the writer's knowledge goes, mineral claims have been staked in only two localities. The first of these is where the Beaver River Gold claims are located, about 30 miles below Tête Jaune Cache. Here, two quartz veins traverse the schists and conglomerates of the Castle Mountain series. The schists are very much contorted, and the veins expand into broad pockets where they cross them, but are much narrower in the conglomerates. The westerly vein is the larger, and can be traced from the north side of Beaver river to near the summit of the mountain south of it. It strikes N 41° W, and dips at about 40° to the southwest. At the largest showing it is 150 feet wide. Here, the quartz is traversed by veinlets of sericite, and at certain points crystals of siderite occur which weather to iron rust on the surface. Near the borders some graphitic and chloritic material occurs, which has doubtless been derived from the dark micaceous schists which form the side walls. It was reported that samples had been assayed and yielded as high as $60 per ton. Chippings taken at intervals across the vein show only traces of gold, and similar chippings taken from a second point higher up where the vein cuts the conglomerate, were no richer. The second vein was examined at a point about a quarter of a mile north of the big showing. It is about 30 feet wide, and contains rather more sericite and siderite, but a sample yielded only a trace of gold. A trail has been cut from the Fraser to within a short distance of the claims.

## Mica Claims South of Tête Jaune Cache.

The second group of claims is situated on the range southwest of Tête Jaune Cache, and on either side of Sand creek. They are located on a pegmatite dike traversing the Shuswap group, and containing large crystals of muscovite of excellent quality. The deposits on Mica mountain were visited by Mr. McEvoy in 1898,[1] and are described in the Annual Report for that year. The deposit examined in 1909 was staked recently by Teare brothers, of Lacombe. Their claims extend from the foot of Mica mountain across Sand creek and to the top of the mountain north of it. The pegmatite dike, where the best showings occur, is over 50 feet wide, and sends stringers into, and includes pieces of, the surrounding schists. The large crystals occur on either side of a central filling of quartz about 5 feet wide. Here, a crystal 14 by 22 inches was found, and many as large as 8 by 10 inches were seen. The quartz of the central vein is massive, white in colour, and more opaque than that in the rest of the pegmatite. The main mass of the latter also contains many crystals of muscovite, but these are smaller, the largest seen measuring about 6 by 8 inches. It is estimated that about 5 per cent of the entire dike was muscovite. Another dike of pegmatite, also about 50 feet wide, occurs about 400 yards east of the first, but the quantity of muscovite in it is much less and the crystals very small. It has no central filling of quartz. The dip of the dikes is nearly vertical, and the first strikes S 21° E. The muscovite is of a slightly greenish cast, but thin lamellæ appear perfectly transparent. Inclusions of ferro-magnesian minerals occur in some crystals, but they are too minute to seriously affect their value.

## Clays, Etc.

Some of the clays on the river bank would probably be found well adapted to the manufacture of brick. Some of the limestones of the Banff series are pure enough to make a good quality of lime. The deposits of peat mentioned are too small and too impure to be of value.

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[1] G.S.C., Annual Report, Vol. XI, Part D, p. 39.

# SLOCAN DISTRICT, BRITISH COLUMBIA.

*(O. E. LeRoy.)*

## INTRODUCTION.

The area covered by the Slocan geological map sheet will comprise about 260 square miles in the mining divisions of Ainsworth and Slocan. It will include all the principal centres in which the mining of silver-lead and zinc ores is being carried on between Kootenay and Slocan lakes, from Fourmile basin on the south, to Whitewater on the north. In this district transportation facilities are afforded by two railways, namely, the Canadian Pacific railway running from Roseberry to Sandon, and the Kaslo and Sandon railway connecting Kaslo with McGuigan. It is hoped that before long the latter road will resume its service into Sandon. Owing to the June freshet, the service was much disorganized this season, and Sandon was without railway communication from June until the latter part of October, thus preventing the shipping of ore during that period.

The greater portion of the area was geologically mapped this season, and a large number of claims and mines were examined. In the case of the latter, the hearty co-operation of the mine owners was of great assistance in facilitating the work. It is expected that about half of another season will be required to complete the sheet. During the season just past the writer was assisted in a most efficient manner by Mr. C. W. Drysdale.

At the present stage of the investigation only a very general statement can be made regarding the geology and the ore deposits, as it is felt that more data are required before making public any definite conclusions.

## TOPOGRAPHY.

The area comprised in the Slocan map sheet lies wholly within the Selkirk range, which here is made up of a series of rugged ridges with no regular trend. The general altitude of the crests varies from 6,000 to nearly 8,000 feet, with an occasional higher peak. The upper portions of the ridges are usually steep and bare, while the lower portions are covered with a mantle of 'wash' or glacial drift of varying thickness.

The district is crossed by one of the main transverse valleys of West Kootenay, extending from Kaslo to New Denver. The valley is occupied by Seaton and Carpenter creeks flowing west, and Kaslo creek flowing east, the divide being at Bear and Fish lakes. The tributaries of these creeks flow with steep gradients in rather sharp V-shaped valleys. Kaslo creek flowing into Kootenay lake, and Wilson, Carpenter, and Fourmile creeks emptying into Slocan lake, have built up considerable deltas, on which are situated the towns of Kaslo, Roseberry, New Denver, and Silverton respectively.

## GENERAL GEOLOGY.

The principal rock series in order of age are the Shuswap, Selkirk, and Slocan. The former is Pre-Cambrian; but at present no definite position as to age can be assigned to the two latter series, owing to the structural relations not having been fully worked out and to the apparent absence of fossils. Besides the above there are numerous intrusions of igneous rocks, ranging from quartz porphyries and granites to diorites and even more basic types. They occur chiefly in the area underlain by the Slocan series.

### Shuswap Series.

The Shuswap series is developed as a comparatively narrow band along the west shore of Kootenay lake, and consists of interbedded quartzites, crystalline limestones, gneisses, and schists, with intercalated sills of granite, diorite, etc. The general strike makes a slight angle with the trend of the shore, and varies from N 15° W to N 25° W, with southwest dips from 45° to 85°. The series also occurs along the west shore of Slocan lake in small, isolated exposures.

### Selkirk Series.

The Selkirk series occupies a roughly triangular area in the north and northeast part of the sheet, and is composed in the main of greenstone schists, with subordinate quartzites, silicified ash rocks, breccias, limestones, and phyllites. Masses of serpentine also occur, and represent completely altered basic intrusives. The trend of the series varies from N 15° W to east and west. No contact has yet been found with the underlying Shuswap, and the contact with the Slocan series, where noted, has the character of a thrust fault along the axis of a sharp fold.

### Slocan Series.

The Slocan series occupies the main area of the sheet, and consists of interbedded dark grey quartzites, black carbonaceous slates and argillites, and grey and black limestones with all grades of transitional types. Adjacent to the granite intrusions the slates and limestones have been altered to andalusite and hornblende schists, and impure marbles respectively. With local exceptions, the general trend is from N 65° W to west, with high dips either to the south or north. Local crush zones accompanying faulting are common, but, so far as noted, the displacements are small.

### Igneous Rocks.

The igneous rocks later than and associated mainly with the Slocan series, are of three ages at least. The oldest intrusives consist of a series of basic dikes and sills which are now almost completely altered to carbonates, mica, and quartz. In Jurassic or post-Jurassic time, quartz-porphyry, fine-grained granite, and quartz-diorite were intruded as dikes, sills, and stocks; they are genetically connected with the main granite batholith to the south, the northern portion of which enters the map area along Fourmile creek and the south fork of Kaslo creek. Cutting all the above rocks is a widespread series of basic mica and hornblende dikes and sills, which form the last evidences of igneous activity in the district.

## ECONOMIC GEOLOGY.

The silver-lead and zinc ores occur in fissure veins in the rocks of the Slocan series, and occasionally in the quartz porphyry and granite. The dry or siliceous ores are found in the two latter rocks or adjacent to them in the quartzite and partly altered slate.

Of the deposits examined, the majority of the fissure veins follow the lines of master jointing in the stratified rocks, with a trend varying from N 25° E to N 80° E, with high dips either to the southeast or northwest. In the Whitewater basin, however, the trend of the veins is about due east with a dip to the south, and the fissures cut across the highly inclined beds of slate and quartzite. The fissures vary in length from a few hundred feet to 4,000 and 5,000 feet, and the width varies from a few inches to 40 or more feet. In the wider portions of the fissures the vein filling is largely crushed country rock.

The ore shoots are generally composite in character, and consist of a series of lenses of either clean or mixed ores of galena and zinc blende, the former in its purer state favouring the hanging-wall as a rule. In the granite the ore bodies are in the nature of stockworks, the ore following the main longitudinal and transverse lines of jointing.

The numerous small intrusions of porphyry have had a marked influence on the ore deposition by rendering the slates more resistant and permitting the existence of cavities.

Tetrahedrite (freibergite—'grey copper') is the most important silver-bearing mineral present with the galena, and occasionally with the blende. Native and ruby silver have but a limited distribution. Chalcopyrite in small quantities is usually present, and pyrite almost invariably, and in increasing quantity as the vein becomes poorer in lead and zinc. The lead-copper sulphate linarite was found in one locality only, occurring as crystals in a mixed ore of galena and chalcopyrite. The gangue mineral in most cases is siderite, with subordinate calcite and quartz. Occasionally the quartz predominates to the almost total exclusion of the siderite.

## MINING.

During 1909, the shipping mines were the Whitewater, Whitewater Deep, Ruth (Hope claim), Richmond-Eureka, Rambler-Cariboo, Lucky Jim, Van-Roi, Cork, Reco, Slocan Star, Slocan Sovereign, Last Chance, Standard, Wellington, Bismark, Flint, Index, Utica, Alama, Gold Cure, Silver Glance, Fisher Maiden, Marion, Molly Hughes, McAllister, and Panama. The three last were producers of dry ore, and the Lucky Jim was the only property worked exclusively for zinc ore.

The Surprise, Washington, Noble Five, Hewitt, Payne, Bluebird, Rio, and Mountain Con are under development, and some of these will shortly become shippers.

Important development work has been carried on this season, which will have considerable influence on deep mining in the district; this includes the cross-cut tunnels on the Whitewater Deep and Sunset, the drift tunnels on the Surprise and Slocan King, and the extension of the lower levels of the Payne mine. If bodies of payable ore are found at these depths, it will stimulate more active prospecting and development on other properties now popularly believed to be worked out.

There are several properties now lying idle which should be producing; some of these afford opportunities for leasing by small companies or groups of individuals, and under a moderate royalty ought to yield satisfactory returns.

## ADDITIONAL FIELD WORK.

### The Cœur D'Alene District, Idaho.

In the early part of May a week was spent in the examination of the geological formations in the vicinity of Wardner and Kellog. Through the courtesy of Mr. Stanly Easton, the writer was given the opportunity to examine the more interesting sections of the Sullivan and Bunker Hill mine.

### The Phœnix Camp.

The latter half of May, and two days in October, were spent at Phœnix in revising the work of the previous year, and in giving such assistance as was possible in prospecting other mineralized areas adjacent to the town.

### The Sheep Creek Camp.

Two days in May, and the first half of July, were spent at Sheep Creek in extending northwards the geological boundaries previously laid down by Dr. R. A. Daly, in order to secure data for the completion of a sketch map of the whole camp.

# TOPOGRAPHICAL WORK IN THE SLOCAN DISTRICT, B.C.

*(W. H. Boyd.)*

The past season—from June to nearly the end of September—was spent in making a topographical survey of the Slocan district for the publication of a map on a scale of 1/62500, or nearly one mile to the inch, with contours at intervals of 100 feet. Mr. H. Matheson, of the Geological Survey, was appointed to act as assistant.

The area of the district to be covered by the map sheet is about 276 square miles: 23 miles east and west, by 12 miles north and south. The sheet includes the towns of Kaslo, Three Forks, Sandon, New Denver, Silverton, and Roseberry, and all the principal mines of the Slocan.

Photo-topographical methods were employed, supplemented by plane-table and stadia traverses of the railways, main roads, and areas around the more important mines. Telemeter and aneroid traverses were also run of trails and some roads, and were found to give very good results for work on this scale.

Owing to the lateness of spring, the snow was very slow in disappearing from the summits and basins, so that during the month of June, and part of July, it was found impossible to carry on the triangulation control for the sheet, since it was very difficult, and in some places impossible, to erect signals or monuments. It was, therefore, found necessary to postpone the control work until later in the season. Work was carried on in the valleys until the snow melted sufficiently to render the summits accessible. Much valuable time, however, was lost from our inability to have the control work done at the beginning of the season. In the future, therefore, for the saving of both time and labour, as well as to secure better work, it would be advisable to endeavour, as far as possible, to have the control work of a district completed before the topographical work is commenced. In the Slocan much more work would have been accomplished, and more satisfactory results obtained, if this course had been followed; as it was, it was found impossible to complete the work this year; hence, about one-third of the area is still unmapped. Field work closed on September 23.

The following field assistants were attached to the party: Messrs. C. C. Galloway, M. S. Archibald, and E. Bartlett. Mr. E. E. Freeland was engaged in the field to complete the necessary staff of assistants. All did their work in a satisfactory manner.

After leaving the Slocan, I accompanied the Director on a visit to the Ainsworth cave, where we spent a day, and then made a trip from Argenta, on Kootenay lake, across the divide to Wilmer, in the Windermere district. On returning to Nelson, I went to Phœnix, where part of a day was occupied in work connected with the mapping of that area the previous summer; after which I left for Ottawa. On my way east, a day was spent with the Director examining Turtle mountain at Frank, Alberta.

## RECONNAISSANCE IN EAST KOOTENAY, B.C.

*(Stuart J. Schofield.)*

### INTRODUCTION.

My instructions for the field season of 1909 were, to study the geology of, and topographically survey an area in East Kootenay, B.C., enclosed by 115° 45′ and 116° 30′ west longitude, and 49° 15′ and 49° 45′ north latitude, the resulting map to be published on a scale of 4 miles to 1 inch. The area thus outlined contains 1,156 square miles, of which the northern half was covered during the season. It lies a short distance north of the International Boundary and east of Kootenay lake. The town of Cranbrook is situated a short distance within the eastern boundary of the sheet.

The photographic method was used in securing the necessary topographical details, and in connexion with this work and the study of geology, Mr. W. J. Galbraith proved a valuable assistant.

A topographical and geological map of the area made in 1899 by J. McEvoy has been published by the Geological Survey. The mining districts have been examined and reported on by W. F. Robertson, Provincial Mineralogist of British Columbia. Much valuable information concerning the economic geology of the district is contained in the Report of the Zinc Commission, published by the Department of the Interior. The geology of the districts immediately south of the present one, along the International Boundary, has been outlined by R. A. Daly in Summary Reports of the Geological Survey.

### GENERAL CHARACTER OF DISTRICT.

The district lies within the Purcell range, which, on the south, is characterized by rather low, wooded hills; while north of Goat River summit the country becomes more rugged, the mountains usually having large glacial cirques sculptured in their precipitous walls. The vertical relief in the more mountainous region is from 4,000 feet to 6,000 feet. In marked contrast to this topography is that of the prairie region situated in Kootenay River valley along the eastern border of the sheet.

The drainage of the area is effected by St. Mary river, flowing easterly into Kootenay river at Fort Steele; Moyie river, emptying into Kootenay river in the State of Idaho; and Goat river, flowing south to Yahk on the Canadian Pacific railway, and thence west to join Kootenay river at its delta on Kootenay lake.

The climate is characterized by dry summers, rather long winters, and wet seasons in May and November. The snowfall in the prairie section is very light, but in the mountains 8 feet of snow is not unusual. For agricultural purposes, irrigation is necessary, and is practised in the prairie sections. Cattle and horses range all the year round in the lowlands if looked after in the months of February and March.

Many valuable timber limits have been located in the region. The trees are spruce, pine, hemlock, cedar, balsam, jackpine, tamarack, and poplar.

The larger animals of the region include the grizzly, cinnamon, and black bears; caribou, deer, goat, mountain lion, wolverine, and lynx. The martin, mink, skunk, weasel, and beaver are now becoming scarce. Marmots, gophers, and porcupines are rather plentiful.

Access to the region is furnished by the Crows Nest branch of the Canadian Pacific railway, and by a branch line from Cranbrook to Kimberly. Numerous good roads exist in the more thickly settled districts; while graded trails built by the provincial government penetrate the mountains.

The principal industries of the district are lumbering, mining, and agriculture.

## GENERAL GEOLOGY.

Since the work of the past season was largely of a preliminary nature, much of the time having been devoted to topographical work, the geology and economic resources of the area are given but brief mention in this report.

The region is largely underlain by sediments, probably of Cambrian, though possibly of Pre-Cambrian age, into which numerous sills of diorite have been injected. A small stock of granite is the youngest rock in the district.

Mountain-building forces, acting probably at the close of the Laramie, have folded and faulted the formations, throwing them into great, open folds, but sometimes giving rise to overturned anticlines, overthrust faults, and mashing.

The chief ore deposits, those of lead-zinc ores, occur in the Kitchener formation, which contains the greater number of igneous intrusions. Copper-bearing deposits, gold-quartz veins and placers also occur within the region.

### TABULAR DESCRIPTION OF FORMATIONS.

| | |
|---|---|
| Pleistocene | Unconsolidated gravels and sands. |
| Jurassic? | Granite. |
| Cambrian? | Moyie formation.—Very thinly bedded, brown and grey weathering quartzites, metargillites and shales. Estimated thickness, 3,500 +. |
| | Gabbro and diorite sills. |
| | Kitchener formation.—Thin bedded, rusty-weathering quartzites, argillaceous quartzites and metargillites. Estimated thickness, 7,500 feet. |
| | Creston formation.—Grey-weathering, heavily bedded quartzites, argillaceous quartzites, and meta-sandstones separated by thin bands of metargillite. Estimated thickness, 9,500 feet. |

*Cambrian?*—The boundaries between the three formations classed as Cambrian, cannot be fixed with any great precision, as the well-bedded rocks of these formations pass gradually and conformably into one another, and no fossils were found to aid in their stratigraphic division. The whole series is classed as Cambrian, though possibly belonging to the Pre-Cambrian. The presence of ripple marks, worm borings, and mud cracks in all of the sediments points to a shallow water origin.

The sills of diorite are numerous in the Creston and Kitchener formations, especially so in the latter. They seem to be absent from the Moyie formation, and, therefore, appear to have been intruded before the deposition of the Moyie beds. The sills sometimes attain a thickness of 400 feet, are more acid at their upper contacts, and become finer grained at both their upper and lower contacts.

*Jurassic: Granite Intrusion.*—On a lake situated at the head of the second creek on the south side of Baker creek, is an intrusive mass of granite (so-called in the field) which is badly smashed, and cuts the Moyie and Kitchener formations. The rock is of a grey colour, and varies from granitic to porphyritic in texture. The mineral constituents are quartz and biotite, with alkali and lime feldspars. Cutting this body are numerous fine-grained aplite dikes. As no younger formations are present, the age of this granite cannot be definitely determined, but is assumed to be Jurassic.

*Pleistocene: Glacial and Recent.*—Numerous records of glaciation are preserved throughout the region. All the lower hills up to the height of about 7,500 feet owe their rounded forms to the action of the Cordilleran glacier. In the higher mountains, glacial cirques containing small lakes may be seen at the headwaters of almost every stream. The valleys are all U-shaped, with meandering stream cutting channels in the flood plains. Hanging valleys characterized by falls are found on all the tributaries of St. Mary river. The direction of glacial striæ was noted in many places, but owing to the difficulty of discriminating between the striæ of the Cordilleran ice-cap and local glaciers, the direction of main ice movement is better determined from the erratics. The general direction seems to be from northwest to southeast.

The lower portions of all valleys are covered with a thick layer of glacial drift, thoroughly cemented by the solution and reprecipitation of calcium carbonate. This enables the drift to stand with steep cut banks, well shown along St. Mary river. The boulders found in the gravels consist of quartzite and diorite, and have not been transported far. More rarely, boulders of grey granite are found, which have probably been derived from a batholith situated about 20 miles northwest of the area examined. Near the present surface the gravels pass gradually into stratified clays and sands, which in the vicinity of the St. Eugene Mission contain two seams of lignite. The following section was measured:—

| | |
|---|---|
| Eroded surface— | |
| Blue clay | 4′–0″ |
| Lignite | 0′–6″ |
| Blue clay | 0′–6″ |
| Lignite | 0′–8″ |
| Blue clay | 2′–0″+ |

The lignite is brownish-black in colour, and crumbles easily. The seams are too thin to be of any economic value. Some of the clays are suitable for the manufacture of brick.

## ECONOMIC GEOLOGY.

The Kitchener formation contains the majority of the metalliferous deposits. As noted above, this formation contains the larger number of gabbro-diorite sills. The examination of the mining properties and prospects was of necessity a hasty one. The deposits fall roughly under four heads: lead-zinc deposits, copper deposits, gold-quartz veins, and placers. The most promising ore-bodies are the lead-zinc deposits, of which the St. Eugene, North Star, and Sullivan are examples. These mines are located in the Kitchener quartzites.

The North Star mine is situated on the east slope of the North Star hill, in an area of disturbed Kitchener quartzites. These form the eastern limb of a huge anticline. They have a general strike of N 75° E (magnetic), and dip 10° to 25° S. The ore mined at present is purely the oxidized product of argentiferous galena and pyrite. It is brown in colour, earthy in appearance, and consists of limonite and cerussite (lead carbonate), with some native silver in moss-like aggregates. When the product of surface alteration has been exhausted the leaner sulphides—consisting of fine-grained galena, pyrite, and zinc blende—will have to be utilized. The hard ore contains very little gangue, and occurs on the axes and limbs of local anticlines, replacing the country rock which, near the vein, is altered to a white quartzite. The ore is mined by means of shafts, tunnels, and open-pits. Not enough work has been done up to the present to make possible any definite statement regarding the size of the deposit and its continuity in depth. The ore is shipped to Trail for treatment. About 25 men are employed, and the output for September, 1909, was 300 tons.

The Sullivan group of claims is fully described in the report of the Zinc Commission on the zinc resources of British Columbia.[1] At the time of the writere's visit, no work was being done on these claims, but since then the property has passed under the control of the Consolidated Mining and Smelting Company, and the output will be shipped to the Trail smelter. The lode is located in the Kitchener formation, on the southern slope of Sullivan hill. The strata in the vicinity of the mine have a general strike of N 50° E, and the dip varies from 10° to 25° S. About half a mile northwest of the mine a large diorite sill is intrusive into the sediments, and a sill of like character is to be found on North Star hill. The ore consists of very fine-grained galena, zinc blende, and pyrite, in intimate mixture. The percentage of zinc varies in different parts of the mine; and at present, the ore—which contains a large amount of zinc—is not utilized. The workings consist of a number of shafts, open-cuts, and one tunnel. These have not as yet exposed the size and relations of the deposit.

Pyramid basin contains a number of Crown-granted claims, and a considerable amount of work has been done; but most of the workings were inaccessible, owing to the filling of the shafts with water, and the caving of tunnels. On one claim, situated in the middle basin in the Kitchener formation, is a 2 ft. vein of arsenopyrite, galena, and pyrite, in a quartz gangue. The deposit is associated with a diorite sill, which has a dip of 50° S, striking N 50° E (magnetic). Situated on the west slope of Evans mountain, in an area of Kitchener rocks, is the Evans group of claims. On the lower claims a tunnel about 200 feet long has been driven into a low grade ore body, which consists of a coarse-grained gabbro-diorite, impregnated with pyrite, copper bearing in part, and pyrrhotite. The ore is found in the interior of a sill, and probably is of the nature of a differentiate. The upper claims have a fissure vein striking N 45° E, bearing chalcopyrite, pyrite, and native copper, in a quartz-calcite gangue. Pollen's claims, located near the above claims and probably in the same sill, contain a vein 8 feet wide, striking S 75° E. The ore consists of chalcopyrite, pyrite, copper-bearing in part, with very little gangue. A peculiarity of this deposit is the association of rather large crystals of pyroxene with the ore. A tunnel about 200 feet long has been driven to open up the deposit.

A number of claims were examined on Perry creek. The ore-bodies consist of quartz veins cutting across the Creston formation in various directions. No information could be obtained concerning these claims, but they were presumably located as free-milling gold propositions. Although no visible gold could be detected, values might be obtained by assay.

The only placer mining in the district is being carried on by the Perry Creek Hydraulic Mining Company, Limited, on Perry creek, about 4 miles above Old Town. Formerly the richest gravels close to bed-rock were worked over by means of tunnelling and sluicing. At present a hydraulicking plant, consisting of 3 miles of flume giving a head of 300 feet at the giant, and a sluice 550 feet long containing 250 feet of riffles, is in operation. The lower portion of the gravels is unsorted, and contains large glacial boulders of quartzite and gabbro-diorite. The upper part of the gravels consists of stratified clays and sands.

The future of the lead-zinc deposits in East Kootenay is dependent on the discovery of some method for separating the zinc mineral before smelting. The ore in the district consists of an intimate mixture of fine-grained galena, sphalerite, and pyrites, which is extremely difficult to separate. For a fuller discussion of the problem, the reader is referred to the report of the British Columbia Zinc Commission.

The copper deposits occur, so far as known, in the gabbro sills, which in the area examined never exceed 500 feet in thickness. Not enough work has been done to prove whether the veins occurring in these sills are continued into the quartzites above and below.

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[1] Zinc Resources of British Columbia, and the conditions affecting their exploitation. W. R. Ingalls, 1905.

# COAL FIELDS SOUTH OF THE GRAND TRUNK PACIFIC RAILWAY, IN THE FOOTHILLS OF THE ROCKY MOUNTAINS, ALBERTA.

*(D. B. Dowling.)*

## INTRODUCTION.

The coal areas of Alberta, although known to be large in extent, are not all—owing to location or quality of product—available for supplying the coal required by the railways; consequently there is still a great demand for coal of the bituminous class, such as is found in the foothills and mountain areas. The areas containing such coal near the present railway lines are fairly well known, and are being exploited as fast as the demand warrants. The completion of the projected transcontinental railways through the Yellowhead pass will extend the market for coal so as to severely tax the producing powers of the present mines; hence, prospecting for coal in the vicinity of the projected lines has been very active.

The Bighorn coal basin, which was discovered in 1906, has been examined by Mr. Malloch of the Geological Survey, whose report will soon be issued. The report will deal with the exposures between the Saskatchewan and the Brazeau. The continuation of the area northward was hurriedly explored this season, and other exposures in the lower foothills were also examined. The results of this rough survey are shown on the small sketch map on page 144 of the present report. The general results of the exploration were the tracing of a long strip of coal-bearing lands reaching northward from the Saskatchewan to the sources of McLeod river, a distance of over 60 miles, and the locating of a smaller area east of Bighorn range. Another area lying in the outer foothills had been exploited previously, but the horizon of the coal was not known.

## SUMMARY AND CONCLUSIONS.

South of the Grand Trunk Pacific Railway line, in the foothills, there are coal fields of large extent. Of these, the nearest to the railway is situated in the outer portion of the disturbed foothills area. From it, domestic, and a fair grade of steam coal may be obtained. The area is situated on the headwaters of Embarras and Pembina rivers, and may be of larger extent than outlined on the accompanying sketch map. Over a portion of this area a seam of from 12 to 17 feet can be mined.

Higher grade, steam and coking coals may be obtained from more distant fields, to which approach is more difficult, since they are situated behind high, rocky ridges. The areas containing the best grade of coal extend in narrow strips from the Saskatchewan river to near the Athabaska, behind the Brazeau, Bighorn, and Nikanassin ranges, respectively. The parts which seem mineable, and easy of approach through gaps in these ridges, may be outlined as: the Brazeau Range area, on the Saskatchewan; the Bighorn basin, from the Saskatchewan to the Brazeau rivers; and the southern part of the Nikanassin basin, drained by the McLeod and North branch of the Brazeau rivers. These areas may not be mineable outside a strip which is not much over a mile in width, but they have a total length of nearly 80 miles. A section of the measures near the Saskatchewan shows nearly 100 feet of workable coal, in about nine seams. Northward, the seams possibly decrease in thickness and number, but on the McLeod the upper part of the coal-bearing horizon was observed to have about 20 feet of coal seams. This may be added to by further prospecting.

The character of the coal is remarkably uniform; and in almost all parts of the field, coking coals that yield 75 per cent of coke may be found. The Fiddle Creek portion, at the northern end of the Nikanassin basin, has not been examined, but it is reported that coal has been found at points within half a mile of the Athabaska. Possibly there are anthracitic coals in this part of the basin, but the location of mineable areas is considered to be of more importance than the finding of harder coals.

## GENERAL CHARACTER OF THE DISTRICT.

### Topography.

The areas considered in this report as coal fields lie within the zone of disturbance on the eastern slope of the Rocky mountains, in the region generally described as the foothills, although including also spurs or short outlying ranges of mountains.

The Rocky mountains here consist of parallel ranges lying comparatively close together; but in the neighbourhood of the Saskatchewan valley, two outlying ranges occur in front of the masses forming the mountains proper. The outer one, Brazeau range, is cut transversely by the Saskatchewan valley, but extends only a short distance to the north of it.

Bighorn range occupies a position midway between Brazeau range and the mountains proper, but lies wholly north of the Saskatchewan, terminating toward the south, on the north side of the valley. The range parallels the Rocky mountains northward to Brazeau river, where it loses elevation, and ends. To the north, after a short break, another range continues to the Athabaska river, which it reaches between Drystone and Fiddle creeks. To this it is proposed to give the name *Nikanassin*, from the Cree words meaning ' outer range.'

The foothill region outside the true mountain areas, may—for descriptive purposes—be divided into two divisions: the rough foothills, and the undulating plateau country.

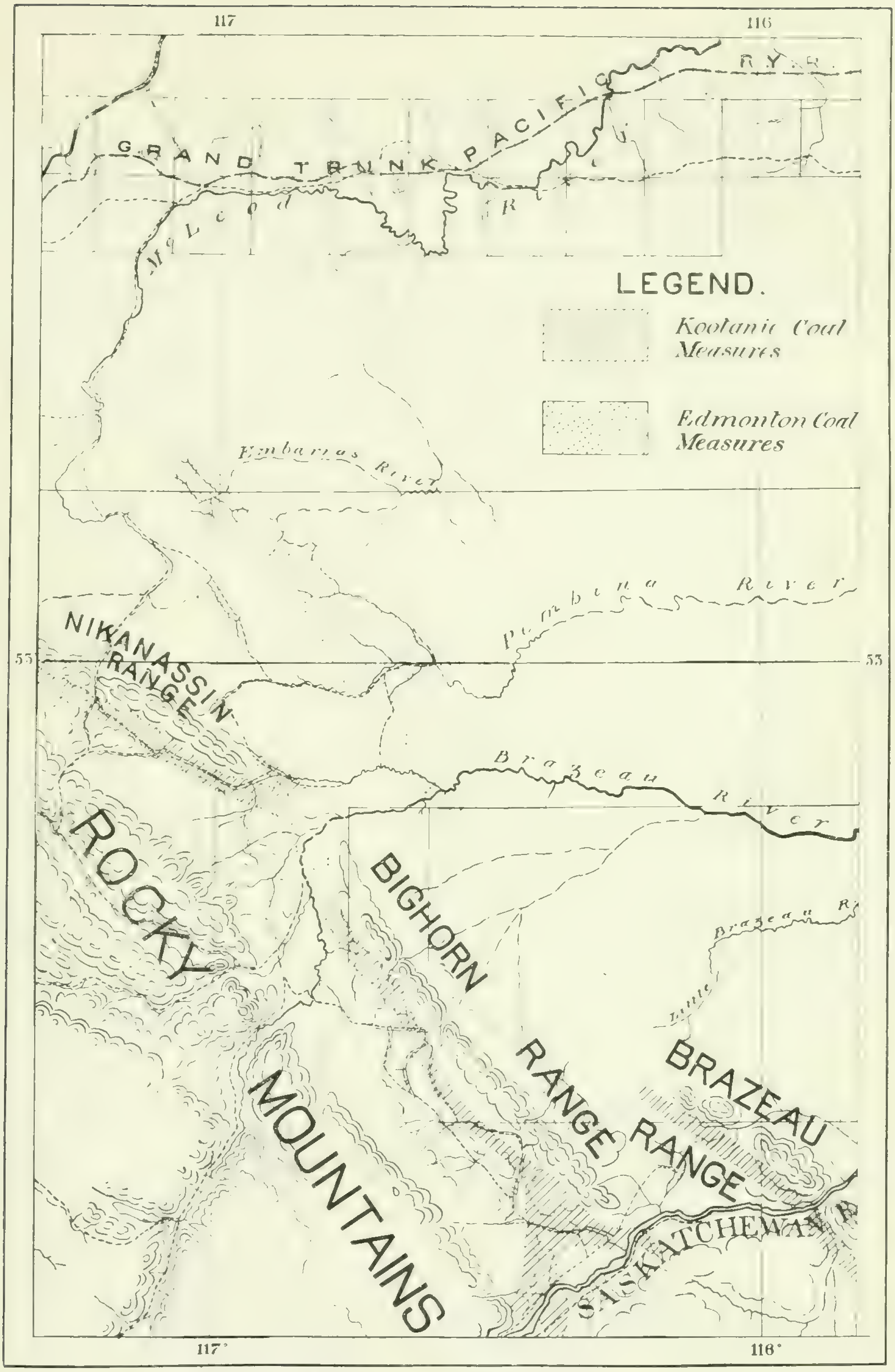
The rough foothills west of the McLeod river form a narrow belt as far south as Pembina river; from there, southward, the belt becomes wider, and the ridges more prominent, so that between Brazeau river and the Saskatchewan the foothills are arranged in very pronounced ridges parallel to the mountains.

The plateau country, bounded on the west by the rough foothills, merges easterly into the undulating country through which the Saskatchewan flows on its way to the more gently rolling prairie.

The greater part of the district drains easterly through the upper Saskatchewan, Brazeau, and Pembina valleys; but to the north there is a northward slope, drained by the McLeod and Embarras rivers.

Both the Saskatchewan and Athabaska occupy deeply-eroded valleys. In the neighbourhood of the mountains, the Athabaska seems to have reached, temporarily at least, a grade at which erosion is proceeding slowly. The Saskatchewan is still a swift stream, transporting a heavy load of coarse gravel, and at times of high water is muddy with finer debris. The Brazeau river, with its many branches, is of next importance, both in volume and extent of incision of its valley through the foothills and mountains. The main branch rises near the source of the Athabaska, although most of its water supply comes from glaciers, near Brazeau lake. Southesk river—the next branch in order of importance—rises near the head of the west branch of Rocky river, which flows into the Athabaska. The remaining tributaries of the Brazeau are the north and south branches, flowing from the outer ranges.

Pembina river is a foothill stream, and does not reach large dimensions within the area under consideration. McLeod river has no distinct valley through the Nikanassin range, its branches flowing northeasterly through several gaps in the range. These, after reaching a northward trending depression, unite to form the main stream.




# COAL AREAS

IN THE FOOTHILLS BETWEEN

## McLEOD AND SASKATCHEWAN RIVERS

ALBERTA

Miles 10 0 10 20 30 Miles

12507—p. 140. Fig. 2.

## Forest.

The whole area may be classed as forested, although much of the forest has been destroyed by fire. Northward from Pembina river, one of these tracts of dead trees, burned years ago, covers a large area near the mountains. Between the Pembina and Brazeau the forest is still green, with local patches of dead timber. Near the Saskatchewan there is more open country, and the forested areas seem to be covered by younger trees, as though the forest was encroaching on former open country. Near the streams, spruce is the principal tree, but most of the hill forests are of Banksian pine, which, as it has a tall, straight, tree trunk free from limbs, is of value for use as timber where great strength is not required.

## Transportation and Communication.

The projected railway is now graded from the east nearly to Wolf river, and rails are laid to Pembina River crossing. A road designed for wagons has been cut out almost to the mountains, but the western portion, owing to the swampy character of the ground, is probably impassable for wagons. Hence, the principal means of transportation during summer is by pack trains (horses) from the Pembina River crossing. Trails have been cut through the forest for freighting and by prospecting parties, in such number that now almost any point may be reached on horseback.

The main trails crossing the district from east to west are: (1) those following the location of the Grand Trunk Pacific railway; (2) trails along the base lines—the principal one being from Rocky Mountain house to the Bighorn range near the 11th base line; and (3) trails following the valleys of Pembina and Brazeau rivers.

The north and south trails leading from the railway line include those from Wolf creek to the mining camps on the head of Embarras and Little Pembina rivers; and another (not well travelled) from Prairie creek which joins a trail up the valley of McLeod river. The last named was the route traversed by Southesk when he penetrated the outer ranges to reach the headwaters of Rocky river. He entered the mountains proper by a stream which is the source of the north branch of the Brazeau.

The southern portion of the country shown on the sketch map can be reached from Laggan, Banff, or Morley, by following trails to the 'Kootenay plains' on the Saskatchewan, and thence north to the Brazeau by trails through the coal fields between the Bighorn range and the main Rockies. These trails are well travelled, and are on hard ground, so that they are preferable to the present approach from the east, which, in places, is through soft muskeg for considerable distances. Trails in a north and south direction in the foothills east of the Bighorn range are very ill-defined. Those shown on the sketch near the mountains are fairly well cut out.

## Commercial Possibilities.

Better access to the district by the construction of railways and roads is all that is needed to ensure the opening up of important coal mines and the utilization of the timber resources. The Saskatchewan valley offers a good route for a railway; since the coal areas to be reached from it are extensive: as are also the agricultural and grazing lands on its slopes. To show that a branch railway up this valley need not be a mere spur line, it may be mentioned that the Howse pass, at the head of the valley, is reported to afford as feasible a route to the Columbia valley as that by the Bow and Kicking Horse river.

Surveys for railways into the Brazeau country are under way, and it is possible that a route through the mountains to Yellowhead pass may be found by the pass from Brazeau lake to the Poboktan; or, possibly, by the headwaters of Southesk river which heads with the west branch of Rocky river. No pass low enough to afford a

route to the valley of Maligne river was found; but connexion might be made by a tunnel through the dividing ridge at its narrowest point. The coal fields at the head of the McLeod valley could be reached by short branch lines up it, from the north.

The advent of railways will make available the excellent steam and coking coals of the Bighorn basin and its extension to the north.

## GENERAL GEOLOGY.

The main ranges of the Rocky mountains are of the fault block type, with local folding or curving, in the vicinity of overthrust faults. These blocks in the outer ranges show a succession of beds ranging from reddish, sandy slates, of Triassic age, exposed on the western slopes of many of the hills, downward through massive Carboniferous limestones to the yellow tinted Devonian. The Bighorn and Nikanassin ranges are the upturned edges of such blocks; but on their western slopes there are found remnants of newer rocks, some of which are upper Cretaceous: for example, the sandy beds of the Belly River series.

The northeastward movement of the fault blocks of the Rocky mountains has in many cases caused an upturn of the beds in front, so that in the Bighorn basin the lower Cretaceous coal-bearing beds lying on the eastern ridges, reappear on the western edge of the fault block in highly tilted and often crumpled beds. In the field north of the Brazeau, this structure was not actually observed, but the presence of drift coal in stream beds in the centre of the belt indicates that the structure is probably similar to that in the Bighorn basin.

In the foothills immediately in front of the outer ranges, exposures of folded beds ranging downward to near the Dakota were observed on Pembina river. But to the east of the zone of disturbance, which was almost mountain building in its effect, there seems to be a fault running parallel to the mountains in the outer foothills, and beyond this line there is found the upper part of the Cretaceous—a great sheet of sandstones and shales of the Edmonton series, covered in some places, by Tertiary sandstones.

The areal distribution of the rocks in this district is greatly influenced by the faults and folds in the bed, which run northwest and southeast. If the formations were mapped they would be indicated, in many cases, by narrow bands having this direction. In a general geological description, the area may be conveniently subdivided into four divisions, which correspond more or less closely to those given under the topographical description. The sequence of formations is given from east to west:—

(1) The plateau country having exposures of upper Cretaceous, and probably some Tertiary beds.

(2) A foothill area made up of Cretaceous rocks, ranging in age from the Dakota to the Belly River, with lower Cretaceous beds upturned in places at the base of the first limestone ridge.

(3) An inner belt of foothills behind a barrier of limestone (Triassic to Devonian in age), having exposures of Cretaceous beds ranging from the Kootanie upward to the Belly River formation.

(4) The mountains proper, showing narrow bands of rocks which repeat the succession from the Devonian to the Triassic.

The formations bearing coal in economic quantities are only two: the Kootanie, and the Edmonton; only thin seams of coal, a few inches thick, are found in the Belly River rocks. The Kootanie, which in the type locality is believed to be of fresh water or inland origin, in this district is of a character that seems to indicate that, during its deposition, the land was low enough to allow the water of the sea to occasionally flood at least the northern portion. At the northern outcrop of the rocks of this formation, coal seams are probably fewer than farther south, and confined to the top of the formation.

*Structure.*—The first great fault along which the lower Cretaceous beds are brought into contact with the younger measures which cover the eastern slopes of the foothill area, is found near Miry creek in the foothills, in front of the Brazeau range. Northwestward, this fault crosses Pembina river 6 or 8 miles west of Little Pembina river, and continues to the head of Prairie creek on the south bank of the Athabaska. Northward from this point it follows the edge of the mountains. The next important break occurs in front of the Bighorn range; and, with some complexities near the Brazeau river, continues northward and crosses the Athabaska at Drystone creek. Between these two breaks the rocks are folded into a trough or syncline, followed west and southwest by an anticline. Throughout the foothills these folds are not greatly compressed; but near the Athabaska river, where the axes of the faults are quite close together, the beds dip at high angles.

The upward displacement of this fault block between the above two main faults, becomes greater toward the north, where the appearance at the surface of pre-Cretaceous, hard limestones marks the beginning of another range. The syncline decreases in importance northward, and the crown of the anticline, in the narrower part of the block, forms the centre of the ridge. This feature is shown in the mountain called Folding mountain at the Athabaska, where the beds exposed are of Carboniferous limestone capped by Triassic and Jurassic beds.

The next fault block is bounded on the east by the westernmost fault above mentioned, and on the west by another which extends along the base of the main Rockies from the Saskatchewan to the north branch of the Brazeau, where it enters the mountains, reaching the Athabaska west of Fiddle creek. The block included between these two fault lines has been uplifted, and its eastern edge uptilted on the block to the east. The lowest beds exposed along the eastern edge are limestones of Devono-Carboniferous age, overlain, except where erosion has removed them, by Triassic, Jurassic, and Cretaceous beds. The western edge has in some places been overridden by the next succeeding blocks of the mountains proper, but in most places the softer Cretaceous beds are buckled back, and in places the block forms a trough with steeply upturned beds along its western border. Where the lateral boundaries approach one another, as they do in the mountains, the block is tilted steeply to the southwest, and the Cretaceous coal-bearing beds will probably be found to show the effects of pressure and folding.

## ECONOMIC GEOLOGY.

### General Character of Coal.

The coal of the Kootanie measures in the Bighorn basin has been carefully examined by several prospectors, and analyses have been published in the Summary Reports for 1907 and 1908, which show that it is a bituminous, or steam coal, with a high carbon content, not generally high in ash, and always low in sulphur. Practical tests with a small coke oven on Bighorn river show that a very high grade of coke can be made. Northward, in places, the fixed carbon content is higher, but it seldom approaches that of an anthracite coal.

The coal of the Edmonton measures in the foothills on Pembina and Embarras rivers is of lower carbon content, and approaches what might be termed a low carbon bituminous coal. Its coke is not as firm as that from the coal fields nearer the mountain. This might be expected, as the measures are younger and have not been subjected to great pressure. The results of analyses of these coals from individual exposures will be found on a subsequent page.

### Distribution.

In the Kootanie measures the coal seams found near the Saskatchewan are well distributed throughout the formation. There appears to be in nine seams a total thickness of 90 feet of workable coal. On George creek—one of the forks of the south

branch of Brazeau river—Mr. McEvoy found ten seams, with 65 feet of workable coal. Near the north end of the range on Wapiabi creek, Mr. Malloch last year discovered four seams near the top of the formation, with about 26 feet of coal. On the north branch of the Brazeau, four seams are exposed in the same part of the measures; and on McLeod river the coal is apparently all in the upper measures.

In the upper part of the Cretaceous, as exposed in the foothills on the Embarras and Little Pembina rivers, the coal seams occur in the Edmonton formation—the horizon in which the Big coal seam on the Saskatchewan, and that at the railway crossing on the Pembina occur.

## Details of Exposures.

*Northern end of Bighorn Basin.*—In the Brazeau valley few exposures have been found, but it is certain that the Coal Measures continue across the valley following the direction of the ridges. Several small streams drain southwestward from the Bighorn range to the Brazeau, and on these exposures of the underlying rocks will probably be found. One such stream visited this season, and provisionally called Race creek, crosses the line between ranges 19 and 20, through section 6 of township 43, range 19. Near the eastern edge of the section there exposed, two coal seams are visible: an upper one of 4 feet, and a lower one of 5′–8″. Both seams are mineable, and appear to be good steam coals, but are not certainly known to be coking coals. The analysis of the heavier seam, by Mr. Wait of the Mines Branch, Department of Mines, shows:—

| | |
|---|---|
| Moisture | 1·64 |
| Volatile combustible matter | 21·14 |
| Fixed carbon | 70·08 |
| Ash | 7·14 |
| | 100·00 |

Coke, coherent, but tender.
Colour of ash, white, inclining to grey.

Other seams may probably be found by trenching, since the measures are concealed over long strips by a clay and gravel covering.

On the main Brazeau, coal seams are reported to occur near the mouth of Southesk river. This part of the valley, owing to the thickness of the river deposits, will require careful examination to determine the limits of the field.

*North Branch Brazeau River.*—The north branch of Brazeau river rises in the outer ranges of the Rocky mountains in two well-defined valleys that join at the eastern edge of the northern coal field. The stream, a short distance below the junction, crosses a fold east of the fault which brought up the ridge to the north, and this fold may represent a continuation of the Bighorn basin. On the south fork the stream crosses the measures nearly at right angles, and several exposed coal seams have been prospected. In descending the stream from the trail crossing, the shales of the Colorado group are found dipping toward the mountains or to the southwest, at angles increasing from 20° to 40°; then sandstones are encountered, supposed to be of the Dakota formation, though the line of demarcation between them and the underlying Kootanie is not apparent. These sandstones are not over 500 feet thick, and coal seams occur just beneath them. The first or upper seam dips nearly south at an angle of 55°, and has a thickness of 10′–5″ (including 8 inches of dirty coal occurring in two streaks near the middle of the seam). An analysis of samples taken across the seam shows it to be a good quality steam—probably coking—coal. The results given by Mr. Wait are:—

Proximate analysis by fast coking—

| | |
|---|---|
| Moisture | 1·22 |
| Volatile combustible matter | 22·11 |
| Fixed carbon | 69·06 |
| Ash | 7·61 |
| | 100·00 |

Coke, firm, coherent—76·67.
Colour of ash, reddish-brown.

Ten feet below this seam a 4 ft. seam may be mined, but the outcrop does not promise well, the coal being very dirty. On the south bank, a few hundred feet below the top seam, a 6 ft. seam of good coal occurs, but there is a local fault in the measures, and the coal may be too much crushed to mine. Below the middle sandstone rib on the south bank, an 8 ft. seam which dips at a steeper angle to the southwest, appears to be unbroken, and is probably a good mineable seam; 2 feet at the bottom is dirty, but the upper 6 feet is of bright, clean, steam coal, and probably a good coking coal. The analysis shows an especially low ash content. Analysis by Mr. Wait:—

Proximate analysis by fast coking—

| | |
|---|---|
| Moisture | 1·42 |
| Volatile combustible matter | 23·76 |
| Fixed carbon | 70·50 |
| Ash | 4·32 |
| | 100·00 |

Coke, firm, coherent—77·82.
Colour of ash, light brown.

Below the confluence of the two forks a few seams of coal are exposed in an anticline of the Kootanie rocks opposite Cardinals grave at the Prairie camp, where the trail to Pembina river turns northward from the north branch of the Brazeau. No prospecting has been done on the measures here, so that very few coal seams have been found, but a group of four seams, close together, is known to occur near the top of the formation, with thicknesses of 2, 3, 3, and 4 feet respectively. These, with a 5 ft. seam, are probably repeated to the east at the narrow cañon, since seams having corresponding thicknesses are found there. A sample from the lower 3 ft. seam, which looked the brightest coal, is certainly of a high grade, judged by Mr. Wait's analysis:—

| | |
|---|---|
| Moisture | 0·66 |
| Volatile combustible matter | 24·52 |
| Fixed carbon | 70·86 |
| Ash | 3·96 |
| | 100·00 |

The north fork of the North Brazeau runs for a long distance parallel to the outer limestone ridge of Nikanassin range, but the exposures are mostly of the lower part of the measures, and show thin coaly streaks only. Considerable faulting and slipping of the beds on one another is apparent, but the hills to the west bordering the valley may contain workable seams. The upward continuation of the stream crosses the measures, but exposures of coal seams were not seen.

Continuing northwesterly along the strike of the rocks after leaving the waters of the Brazeau, the drainage is northward. Streams from the mountains cross the

Nikanassin range through three gaps, joining outside to form the McLeod river. On the first branch north of the Brazeau, exposures of coal seams were staked by Thos. Russell in 1906. A thick seam near the stakes measures 12 feet, and the weathered coal sampled across the section (including dirty coal) shows, on analysis, high ash, but remarkably low fixed carbon.

Analysis by F. G. Wait, of coal from 12 ft. seam, Russell claim, head of McLeod river, township 46, range 23, west of the 5th meridian:—

| | |
|---|---|
| Moisture | 5·79 |
| Volatile combustible matter | 22·68 |
| Fixed carbon | 50·97 |
| Ash | 20·56 |
| | 100·00 |

Coke, non-coherent—71·53.
Colour of ash, light brown.

Below this seam, near the creek bed, a small, clean-looking coal seam 2′–3″ in thickness was also sampled for comparison, in order to determine if the beds were changing in general character. This coal is of the same general grade as those to the south, giving the following results:—

| | |
|---|---|
| Moisture | 1·18 |
| Volatile combustible | 21·46 |
| Fixed carbon | 73·10 |
| Ash | 4·26 |
| | 100·00 |

Coke, firm, coherent—77·36.
Colour of ash, bluish-grey.

Several small seams were found in the same creek below the large one mentioned, but were all too small to work.

In the third opening, through which the largest branch issues, the measures were found and reported on by R. W. Jones, C.E., whose samples were analysed by Mr. J. O'Sullivan, provincial assayer for British Columbia. A seam, which is perhaps a continuation of the 12 ft. Russell seam, but measures 7′–6″, gave the following analysis:—

| | |
|---|---|
| Moisture | 1·0 |
| Volatile combustible | 27·5 |
| Fixed carbon | 56·5 |
| Ash | 15·0 |
| | 100·0 |

Coke, hard and firm.

Another, with a thickness of 4′–6″, is of better quality both in respect to ash and fixed carbon content, having:—

| | |
|---|---|
| Moisture | 1·5 |
| Volatile combustible | 30·5 |
| Fixed carbon | 61·5 |
| Ash | 6·5 |
| | 100·0 |

Coke, hard and firm.

This series of coal-bearing rocks extends into the mountains and continues on, west of the Nikanassin range, to the Athabaska; but the basin appears to be narrower, owing to the convergence of the fault lines between which it lies. In this area of great pressure and folding, coals may be found, having anthracitic characteristics.

*Brazeau Range Coal Basin.*—Exposures on Miry creek show that another belt of Kootanie rocks crosses the valley of the Saskatchewan east of the Bighorn range. These rocks were not critically examined owing to lack of time, and no coal seams were discovered in them, but no doubt seams will be found in them when the construction of a railway line up the valley is begun.

*Pembina and Embarras Coal Field.*—The coal seams on the Little Pembina seem to occur at about the horizon of the top of the Edmonton formation, like the thick seams at the railway crossing on the main river.

The valley of the Little Pembina seems to follow a line of fracture, from which the loose material has been removed; the exposures near its mouth on the Pembina river show this, and also those at the prospecting camp, where a 12 ft. seam in one place is found buckled back, so that the face of the bank shows an exposure of broken coal 25 feet between the walls. At other points, not visited, it is reported, though the reports are probably exaggerated, that local swells in the seams give thicknesses as great as 42 feet. The thickness of the undisturbed seam does not appear to be less than 12 feet, and in places increases to 17 feet. This coal, which has been altered by pressure to a coal of the bituminous class, may fall below that class in its undisturbed portions. A sample from the 25 ft. exposure gave the following analysis. (It is tabulated for comparison with one from the undisturbed coal seam nearby.)

| | 35 ft. mass. | 12 ft. seam. |
|---|---|---|
| Moisture | 4·32 | 6·32 |
| Volatile | 33·52 | 35·71 |
| Fixed carbon | 57·02 | 52·25 |
| Ash | 5·14 | 5·72 |
| | 100·00 | 100·00 |

The area underlain by this seam appears to be large, since the beds dip gently to the west; it would seem advisable, therefore, to test the ground by boring before mining operations are actually begun. The lease for this area is held by the 'Pacific Pass Coal and Coke Company,' who are prospecting on the Little Pembina.

Another Company, 'The Yellowhead Pass Coal and Coke Company,' has under lease an area in townships 48 and 49, ranges 20 and 22, west of the 5th meridian, on the upper waters of Embarras river. Extensive prospecting operations have been carried out this year under the general charge of Mr. F. B. Smith, from whose report the following notes were obtained:—

The coal field forms the southwestern portion of an anticline, the crest of which is to the northeast of the property. The strike of the beds and the outcrop of the seams run in a northwest direction. The dip of the beds near the crest of the anticline is about 55° from the horizontal. To the southwest the upper members of the series have gentler dips, and are, consequently, less disturbed.

Two heavy beds or deposits of coal are found, separated by 1,500 feet of sandstones and shales. The lower one shows in places a great thickness of coal; but is so impure that without special means for cleaning or washing, it would not be all available. Its greatest thickness is found east of the outcrop near Embarras river, where it shows about 36 feet of coaly beds forming two benches: an upper one of 24 feet separated by 2 feet of shale from the lower 12 ft. bench; it probably thins out materially toward the edges of the field.

The upper heavy deposit or series of seams is found distributed through from 50 to 100 feet of beds. The prospecting on this, at points distributed over a distance of 3½ miles of outcrop, shows a coal content of 35 feet, occasionally increased to 50 feet. Of this coal, two benches seem to be fairly constant, with 9 feet of coal in each. Other seams at the centre of the section may in places allow of an additional amount being included in the estimate of workable coal.

The character of the coal from the upper part of this series of seams may be seen from the following analysis made for the Company by the Milton Hersey Company, Limited:—

Prospect opening B 3, upper bench coal 9′–6″.—

| | |
|---|---|
| Moisture | 8·42 |
| Volatile combustible matter | 38·88 |
| Fixed carbon | 45·50 |
| Ash | 7·20 |
| | 100·00 |

Heating value in B.T.U.—10·982.

The coal from the lower part of this horizon was also sampled in the same locality, from a 7 ft. bench—the upper part of a lower seam, which is here about 17 feet in thickness. The analysis was also by the Milton Hersey Company:—

Prospect opening B 3, lower bench.—

| | |
|---|---|
| Moisture | 5·40 |
| Volatile combustible matter | 37·17 |
| Fixed carbon | 49·33 |
| Ash | 8·10 |
| | 100·00 |

Heating value in B.T.U.—11·957.

These two analyses show the lower coal to be decidedly superior to the upper.

*Other Reported Areas.*—It is quite possible that an extension of the seams described above may be found on McLeod river. The character of the coal is, however, not of sufficiently high grade to place it in serious competition with that obtainable near the mountains. Along the projected railway, coal of lower grade has been found in several places. Brief descriptions of these, with analyses, follow.

An 8 ft. seam is exposed on a branch of Prairie creek which is crossed by the railway just below Brulé lake on the Athabaska river. It gave the following analysis—an average of three samples:—

| | |
|---|---|
| Moisture | 10·10 |
| Volatile combustible matter | 37·54 |
| Fixed carbon | 45·07 |
| Ash | 7·29 |
| | 100·00 |

A smaller seam in the same locality, 2′–3″ in thickness, and hardly workable, had:—

| | |
|---|---|
| Moisture | 4·80 |
| Volatile combustible matter | 33·20 |
| Fixed carbon | 43·10 |
| Ash | 18·90 |
| | 100·00 |

Several seams outcrop on the Athabaska river, above the mouth of the McLeod. An outcrop near the mouth of Oldman river is reported to be of workable thickness, and a sample received from there is superior to the average from this locality. The sample is apparently a coking coal, or very nearly approaches one. Analysis by F. G. Wait:—

| | |
|---|---|
| Moisture | 6·97 |
| Volatile combustible matter | 37·85 |
| Fixed carbon | 48·77 |
| Ash | 6·41 |
| | 100·00 |

Coke, firm, coherent—55·18.
Colour of ash, brown.

On the Athabaska, 20 miles above the mouth of the McLeod, two seams are known that are 10 feet and 3 feet, respectively, in thickness. The following analyses are from Geological Survey Reports:—

| | | |
|---|---|---|
| Thickness of seam | 10′–0″ | 3′–0″ |
| Moisture | 11·47 | 10·58 |
| Volatile | 32·09 | 32·79 |
| Fixed carbon | 47·79 | 50·19 |
| Ash | 8·65 | 6·44 |
| | 100·00 | 100·00 |

Samples sent in for examination from seams near the railway, the thicknesses of which were not given, gave the following analyses, from which their character may be inferred:—

McLeod river, near railway. Sample contained:—

| | |
|---|---|
| Moisture | 9·47 |
| Volatile combustible | 39·24 |
| Fixed carbon | 48·25 |
| Ash | 3·04 |
| | 100·00 |

A sample from Jocks crossing contained:—

| | |
|---|---|
| Moisture | 10·21 |
| Volatile combustible | 38·17 |
| Fixed carbon | 43·52 |
| Ash | 8·10 |
| | 100·00 |

A sample from near Wolf creek, in township 52, range 15, west of the 5th meridian, contained:—

| | |
|---|---|
| Moisture | 8·57 |
| Volatile combustible | 40·39 |
| Fixed carbon | 46·74 |
| Ash | 4·30 |
| | 100·00 |

These samples are very little higher in fixed carbon content than the coal from the railway crossing of the Pembina, the general character of which is indicated by the following analyses of two seams, exposed in the banks:—

| | | |
|---|---|---|
| Thickness of seams.. | 13′–0″ | 6′–0″ |
| Moisture.. | 13·78 | 13·07 |
| Volatile combustible.. | 32·01 | 32·03 |
| Fixed carbon.. | 47·35 | 47·56 |
| Ash.. | 6·86 | 7·34 |
| | 100·00 | 100·00 |

## Kootanie Coal Measures in Smoky River Basin.

Samples of coal, with a few fossils, were submitted by Mr. J. R. Akin, from exposures on branches of Muskeg river, in sections 2 and 4, township 57, range 7, west of the 6th meridian.

The fossils (a few leaves and bivalve shells) are identified by Mr. F. H. Knowlton, of the United States Geological Survey, as being *Zamites acutipennis*, Heer, a plant of the Kootanie formation. The shells are a marine genus, *Tancredia*, found also in the Jurassic. The analysis of one of the samples of coal by Mr. F. G. Wait shows that it is similar in character to that in the Brazeau field, having:—

| | |
|---|---|
| Moisture.. | 1·22 |
| Volatile combustible.. | 24·38 |
| Fixed carbon.. | 68·67 |
| Ash.. | 5·73 |
| | 100·00 |

Coke, firm, and coherent—74·40.

Several seams are reported, but there appears to be on each section a seam between 8 and 10 feet thick, in beds inclined at about 45° to the horizontal. This occurrence is possibly the southern end of a large area which crosses the Peace river in the vicinity of the mountains.

## General Development.

Although considerable expense has been incurred in the purchase and rental of lands, as well as in location surveys, active work in the line of testing the seams has been confined to sending out small parties during the summer months to do excavating by hand. In the Bighorn basin, the seams are fairly well known, and have been reported on. A small coke oven was built on Bighorn creek, and the coke produced was of the best class.

On the Little Pembina, the Pacific Pass Coal and Coke Company have built several small houses, and maintain a staff of prospectors to open the seams of that neighbourhood. The Yellowhead Pass Coal and Coke Company, on Embarras river, have also established a camp on their holdings.

## LAC LARONGE DISTRICT, SASKATCHEWAN.

*(William McInnes.)*

### DISTRICT EXPLORED.

The district explored lies in the northern part of the Province of Saskatchewan. It embraces the country in the neighbourhood of Lac LaRonge, including Nemeiben or Sucker lake to the west, Wapawekka lake (Bear or Pipe lake) to the east, and a part of Churchill river to the north.

Micrometer telescope surveys were made of Lac LaRonge, including the large expansion to the east known as Trout lake, but exclusive of the west shore and adjoining islands, which were being surveyed by L. R. Ord, D.L.S., for the Surveys Branch of the Interior Department; Wapawekka lake; Rapid river and lakes; and a chain of lakes forming a portage route between Lac LaRonge and Stanley.

### PREVIOUS WORK.

The region was visited by D. B. Dowling in 1892, who published a brief description of the lake in Vol. VIII of the Geological Survey reports, pp. 101-102 D; and by the writer in the autumn of 1908 (see Summary Report of the Geological Survey of that year, pp. 80, 82).

The exploration of 1909 was undertaken primarily for the purpose of ascertaining the value of the minerals of the district. Thomas Firth, B.A., acted as assistant, and performed the duties required in a most satisfactory manner.

### SUMMARY AND CONCLUSION.

A series of rocks resembling in many respects the Grenville series of eastern Canada, and which, for convenience of reference, is called the Lac LaRonge series, was found, in certain bands, to be impregnated with sulphides. Many locations have been staked on bands of this description both on Lac LaRonge and on Churchill river, and a little assessment work has been done on some of them. The result of assays of material taken from typical locations has been uniformly disappointing.

At the southern end of Lac LaRonge, the Pre-Cambrian rocks are overlain unconformably by limestone of Devonian age; and farther east, along the south shore of Wapawekka lake, by Cretaceous sediments, thought to be of Dakota age. The Cretaceous is made up in the main of white quartz sands and sandstones, very free of impurities, and well adapted for the manufacture of glass. They contain also a bed of lignite that, where exposed on the shore of the lake, has a thickness of 20 inches of clean coal.

### GENERAL DESCRIPTION.

#### Topography.

The country is a gently rolling, profoundly eroded plateau region or peneplain, lying at an elevation of about 1,200 feet above the sea. It is intersected by many streams and lakes that occupy only moderate depressions in the surface. Excepting in the south, where newer sediments overlap the ancient land surface and the Wapawekka hills form a conspicuous ridge 800 feet or more above the general level, there are no prominent elevations. The general drainage is northward and eastward to Hudson bay. The most important watercourse is the Churchill river, which flows

easterly through the northern part of the area. In this part of its course, 600 miles or more from Hudson bay, it is already a river of large volume, flowing like most of the rivers draining the great Pre-Cambrian peneplain, through a series of wide, irregular, lake-like expansions connected by short rapids and falls. Rapid river, the outlet of Lac LaRonge and its upward extension, Montreal river, drains the greater part of the district, flowing northerly into the Churchill river. The water of Wapawekka lake flows easterly into Pelican lake and reaches the Saskatchewan river by way of Sturgeon-weir river.

The river valleys of the old, Pre-Cambrian peneplain occupy pre-glacial depressions in the rock surface; the valley of the Churchill river is an instance in point, the river flowing over the rims of succeeding rock basins with little erosive effect. On the other hand, the river valleys of the southern part of the area are now in course of very active erosion by the rivers that occupy them. Montreal river is a good example of a river flowing in such a valley, showing, as it does, at a number of points along its course, high scarped banks where widening of the valley by the undermining action of the current is progressing at a rapid rate.

## Transportation.

The district can be reached in summer only by canoe routes, of which there are two principal ones: one from Prince Albert, by an 80 mile portage to Montreal lake and down that lake and the river flowing from it, a distance of 125 miles or more, to Lac LaRonge; the other from The Pas, the present terminus of the Hudson Bay branch of the Canadian Northern railway, by the Saskatchewan, Sturgeon-weir, and Churchill rivers. In winter, when it is most easily accessible, the district may be reached by a sleigh road about 160 miles long. Over this route the fur companies do most of their freighting. A branch of the Canadian Northern railway, now building northwesterly through the settlement on Shell brook, will shorten the distance by only a few miles.

## Commercial Possibilities.

A considerable area of good agricultural land is crossed by the road leading from Prince Albert to Montreal lake, a continuation eastward of the area of such land traversed by the railway along Shell brook. To the north, throughout the whole region about Lac LaRonge and the Churchill river, the areas of good land are not of great extent, the larger part of the surface being either too sandy or too rocky for general cultivation. Limited areas, chiefly about the northeastern part of Lac La-Ronge and along the Churchill river, have a surface cover of clay that provides a fair soil for agriculture.

## Climate.

Though the winters are long and severe, the summer temperatures are relatively high, and the hours of possible sunshine long in this high latitude: about 180 hours or ten days (reckoned in sunshine) longer than in central Ontario during the months of June, July, and August. For this reason the seasons are quite long enough for the ripening of grain crops. On August 7, at Stanley, on the Churchill river (N lat. 55° 25′), potatoes were in full flower, and small fields of wheat, barley, and oats, planted about May 20, were well grown; the wheat stalks averaged 30 inches in height, and the grain was in the milk and beginning to harden. About August 20, a good crop of wheat and oats was harvested from a small area under cultivation at the Anglican mission on Lac LaRonge. At both places good garden vegetables of the ordinary kinds were successfully grown.

### Fauna and Flora.

Large game is not plentiful in the immediate neighbourhood of Lac LaRonge. In the country to the south of the lake, however, where the browsing is better, moose are numerous; while about Red Deer lake and in the country to the south of it Virginia deer are found. The common fur-bearing animals of northern Canada occur throughout the district, and ducks of various kinds breed about the lakes and ponds.

Fish are abundant throughout the region: lake trout and whitefish of good size and quality are plentiful in Lac LaRonge, and whitefish in Churchill river and its lake expansions; while pike of good size occur in all the lakes.

The larger trees occurring in the district are white, black, and balsam spruces (the first named constituting the lumber tree of the district); tamarack; Banksian pine; aspen and balsam poplar, and white birch. Ash-leaved maple grows as far north as the south shore of Lac LaRonge.

The greater part of the region has been repeatedly burned over, only a few islands and small local areas having escaped. The largest of these unburnt areas lies to the south of Lac LaRonge and east of Montreal river, where large white spruces cover a belt extending south from the lake shore.

## GENERAL GEOLOGY.

The greater part of the region under consideration is underlain by the very old rocks of the pre-Cambrian complex. They consist of biotite gneisses of various kinds; crystalline limestone; chloritic, hornblendic, and other schists; diorites; diabases, etc.; with many intrusive masses and dikes of pegmatite and granite. Though over certain areas, notably on the eastern shores of Trout bay, the fine gneisses, associated with sill-like bands of coarse gneiss and pegmatite, lie in a gently undulating attitude, yet over the greater part of the area, they dip at high angles and preserve a very uniform northeasterly strike. Lying on the upturned, profoundly eroded edges of the old schists and gneisses, in the southern part of the area, are two series of newer sediments. On the north shore of Lac LaRonge these consist of fossiliferous, magnesian limestone of Devonian age; while farther east, on Bear lake, lignite-bearing sands and sandstones of Cretaceous age directly overlie the Pre-Cambrian.

### TABLE OF FORMATIONS.

*Quaternary*—
- Recent:—Lacustrine clays, sands, and river sands and gravels.
- Pleistocene:—Morainic boulder ridges and erratics.

*Mesozoic*—
- Cretaceous—
  - Dakota:—White quartz sands and sandstones, with lenticular beds of quartzite grit and conglomerate (lignite bearing).

*Palæozoic*—
- Devonian:—Buff-coloured magnesian limestones, sandstone and conglomerate (fossiliferous).

*Pre-Cambrian*—
- Lac LaRonge Series:—Fine biotite gneisses, augen gneisses, quartz schists, crystalline limestone, etc.
- Keewatin:—Chloritic and hornblende schists, diorite, diabase, etc.
- Laurentian:—Biotite, granite gneisses.

*Igneous*—
- Biotite granite and pegmatites.
- Diorite.

## Pre-Cambrian and Igneous.

Rocks of Pre-Cambrian age underlie the greater part of the shores of Lac La-Ronge and its many islands. They consist, in the main, of a series of gneissic and schistose rocks, all greatly metamorphosed, and showing the effects of pressure and shearing. Biotite-granite gneisses are exposed over a considerable part of the area, and infolded with them are fine, banded and stretched 'beaded' biotite gneisses (see illustration, page 102 D, Vol. VIII, G.S.C.); augen gneisses; quartz schists, in places calcareous; and crystalline, white magnesian limestones. The limestones form a band, 1 to 5 chains wide, conforming in dip and strike to the general trend of the gneisses. The band is made up of magnesian limestones of varying purity, all of which are quite crystalline in structure. All about Lac LaRonge the dips keep a very regular northwesterly direction and high angle, reversing along the east shore to southeasterly, and becoming, still farther east, horizontal or undulating. There is evidence to show that some of the folds are overturned, so that in a section across the strike there is a repetition of the strata.

The general lithological resemblance of this set of rocks to the Grenville of eastern Canada is strong, and the occurrence in them of white crystalline limestone, quite similar in character to the bands of that rock in eastern areas, makes the resemblance more striking.

On Wapawekka lake, a series of diorites and schists of various kinds, that can with some certainty be referred to the Keewatin, appears as a broad belt, emerging from beneath the flatlying sandstones of the Cretaceous and trending almost due east. This is the fifth belt of such rocks now known to occur, between Lake Winnipeg and Lac LaRonge, in this relationship: namely, protruding from underneath the overlapping sedimentary cap and rapidly tapering to extinction in the gneisses. Small boss-like and lenticular areas of diorite and schist, resembling the Keewatin lithologically, occur at other points, in the area mainly covered by gneisses.

## Igneous.

Red granite made up of quartz, orthoclase, feldspar, and biotite mica, generally rich in quartz and poor in mica, and varying in grain from coarse to fine, outcrops over a considerable area along the eastern part of Wapawekka lake. Pegmatite invades the fine gneisses, as dikes, sill-like bands, and irregular masses almost everywhere. Diorite, in a few places, invades and sends apophyses into the fine gneisses.

## Devonian.

No strata of this age were found that were certainly in place, but the occurrence along the south shore of Lac LaRonge of large angular blocks of buff-coloured magnesian limestone or dolomite, with fossils that indicate Devonian age, leads to the belief that they are in place immediately below. The debris of this limestone, mingled with blocks of buff-coloured, calcareous sandstone, and angular pieces of a conglomerate holding pebbles of limestone and quartz cemented by a calcareous arenaceous paste, occurs at some points in such quantity as to make up the whole shore, to the total exclusion of other rocks. Fossils collected from these rocks are thus described by Mr. Lambe of this department:—

'The Lac LaRonge fossils consist of mature and immature specimens of *Atrypa reticularis* L., and of portions of the stems of crinoids. Some of the mature specimens of the brachiopod show the "marginal fringe" so well preserved in a number of examples of this species from the dolomites of the Winnipegosis district. The fragments of crinoid stems agree in form with those, from the Winnipegosis region, referred by Dr. Whiteaves to a species of Ctenocrinus. They are of Devonian age, at about the horizon of the "Stringocephalus zone" (middle Devonian).'

### Cretaceous.

Along the south shore of Wapawekka lake are scarped banks of white quartz sands, in places coherent enough to form a sandstone.

Though no fossils were found in these rocks, they are assigned, with some degree of confidence, to the Dakota division of the upper Cretaceous, from their strong lithological similarity to strata of this age elsewhere, together with their stratigraphical relationship to the older rocks.

### Pleistocene.

The only deposits in the district that can be assigned this age are morainic ridges of boulders, in the southern part of the area; and erratics, scattered everywhere over the Pre-Cambrian peneplain. The region has been strongly glaciated, mainly by a glacier moving in a direction S 30° W as indicated by 'crag and tail' surfaces, chatter marks, and the prevalent striæ. This direction is quite in accord with the generally accepted idea of the direction of movement of the Continental glacier. Not so easy of explanation are other striæ, strong, and marking well the direction of the ice sheet producing them, that are found both at the shore and on neighbouring hills, near Trout narrows, on the east side of Lac LaRonge. Their direction is S 45° E, and they plainly override an earlier, southwesterly glaciation.

### Post-Pleistocene.

The entire southern part of the district between the south shore of Lac LaRonge and the North Saskatchewan river is covered by heavy deposits of post-Pleistocene sands and clays.

Sections of a part of the sands are seen in scarped banks along the course of Montreal river. These show 40 feet of finely-laminated, horizontally-bedded sand, succeeded by 10 feet of sand characterized by very marked false bedding, where the stratification is contorted in a most intricate manner, overlain by 15 feet of fairly regularly stratified sand, extending to the present, plateau-like surface.

Beds of river silt and sands, made up of rearranged material derived from the sands just referred to, are being laid down in the valley.

## ECONOMIC GEOLOGY.

Certain bands in the fine gneisses and schists of the Pre-Cambrian of Lac LaRonge and the Churchill river, are richly mineralized with sulphides of iron, and sparingly with copper sulphides. In the Summary Report of the Geological Survey for 1908, the results of six assays of material from these localities were given. None gave more than traces of gold or nickel. It was then stated that, so far as observed, copper had not been found in sufficient quantity to be commercially valuable. Observations made this summer have served to confirm the opinion then expressed. The results of assays of material taken this summer from two locations on Lac LaRonge and from two on Churchill river are no more promising than those of last year. The assays were as follows:—

LABORATORY OF MINES BRANCH, DEPARTMENT OF MINES.

No. 1477. Quartz from Bearcave hill, Churchill river:—
Gold.......................................... trace.

No. 1478. Siliceous rocks from Churchill river below the mouth of Rapid river:—
Gold.......................................... trace.

MILTON HERSEY CO., L 15, MONTREAL.

Certificate of assay of two samples:—

No. 7 (sample from north end of Mineral island, Lac LaRonge):—

| | |
|---|---|
| Gold | trace. |
| Silver | none. |
| Nickel | trace. |

No. 8 (sample from near south end of Mineral island, Lac LaRonge):—

| | |
|---|---|
| Gold | trace. |
| Silver | none. |
| Nickel | none. |

It may be said then, that exploration in the district, so far, has not yet resulted in the finding of copper in commercial quantity; and that the sulphide-bearing belts on which most of the locations have been staked, do not promise to yield either gold or nickel in payable quantity.

A little assessment work was done on a few properties on Lac LaRonge, and a shot or two put in on Churchill river; but, with these exceptions, no actual mining has been carried on.

## Lignite.

In the white, quartz sands and sandstones, exposed in cliffs, on the south shore of Wapawekka lake, a bed of lignite occurs, varying in thickness from 4′–1″ (with a sandy 6 inch parting in the middle) to 2′–5″ of fairly clean lignite. The seam lies about horizontal, and was traced in a longitudinal direction for a distance of 3¼ miles, following the windings of the shore, thinning out westerly, or being represented by very dirty lignite or highly carbonaceous beds of sand; and not traceable farther easterly, owing to the higher encroachment of talus on the scarped face of the cliffs.

A proximate analysis, by fast coking, of a sample of this lignite, made by F. G. Wait of the Mines Branch, Department of Mines, gave the following results:—

| | |
|---|---|
| Moisture | 11·23 |
| Volatile combustible matter | 30·97 |
| Fixed carbon | 34·80 |
| Ash | 23·00 |
| | 100·00 |

Coke, non-coherent—57·80.
Fuel ratio—1:1·13.
Colour of ash, light orange.
Split volatile ratio—1·88.

From this analysis it will be noted that, were it not for the rather high ash percentage—which is, probably, owing partly to included sand—this might be classed as a fairly lignite coal.

The seam is at its best at the extreme southwesterly point of the bay, where it attains both its greatest thickness and greatest purity. Northeastward and northwestward along the shore, it deteriorates both in size and purity; hence, there is a reasonable probability that in the country farther south, back from the lake, where it is not exposed, the seam may be better.

An analysis by Mr. Wait of a sample received in 1907, and described as 'from an unsurveyed area lying northwest of Cumberland lake, Saskatchewan,' is, from the marked agreement between the two, probably either from the same bed or from one occurring in the same strata elsewhere. It gave the following results:—

| | |
|---|---|
| Moisture | 13·25 |
| Volatile combustible matter | 28·97 |
| Fixed carbon | 34·80 |
| Ash | 23·00 |
| | 100·00 |

Coke, non-coherent—57·78.
Fuel ratio—1 : 1·19.
Split volatile ratio—1·76.

## Glass Sand.

The white quartz sand and loosely coherent sandstone, occurring as thick beds in the Dakota formation, on the south shore of Wapawekka lake, seem to be well adapted for the manufacture of glass. The quartz grains are subangular and are fairly uniform in size, about 93 per cent passing through a 60 mesh sieve. An unwashed sample of the sand, collected from the face of a scarped bank, was analysed by H. A. Leverin of the Mines Branch. It gave the following result:—

| | |
|---|---|
| $SiO_2$ (Silica) | 98·60 |
| $Fe_2O_3$ (Iron oxide) $Al_2O_3$ (Alumina) | 1·20 |
| Other impurities | 0·20 |
| | 100·00 |

As neither the iron oxide nor the alumina occur in the grains of quartz, but rather as coating and cementing materials, this sand after washing should be very pure indeed. The sands occur in cliffs 30 to 40 feet high, facing the lake, and are so loosely coherent as to be easily reduced and collected by the hydraulic method. Certain bands in the crystalline limestone of Lac LaRonge seem to be well adapted to furnish the lime and limestone that would be necessary in glass making. Though now inaccessible by reason of distance, these sands are commercially interesting from their close association with the lignite already referred to, and from the probability of their occurrence elsewhere in the west, in close proximity to a supply of natural gas.

## Lime.

Crystalline, magnesian limestone occurs in a belt several chains wide, extending from Lac LaRonge through to the Churchill river. Thick bands of this limestone are quite suitable for burning for lime. Cliffs of the limestone border the left bank of Rapid river just above its inflow into Iskwatikan lake, the trend of the band being northeasterly (N 53° E), toward the Churchill river, which it strikes near the mouth of Rapid river; and southwesterly toward Lac LaRonge, where it forms low cliffs on some of the islands. From their highly magnesian character these limestones might also prove of value in the operation of manufacturing wood pulp by the chemical process, in the event of such an industry being inaugurated.

# SIMCOE DISTRICT, ONTARIO.

*(W. A. Johnston.)*

## INTRODUCTION.

### General Statement.

The field work of the past season consisted of the topographical and geological mapping of a portion of the Lake Simcoe district, Ontario. This part of Ontario includes an area for which good topographical maps are almost entirely wanting, and in which little geological work has been done since the early exploratory work of the Geological Survey over fifty years ago. The geology of the district, although for the most part of a non-economic nature, on account of the absence, generally, of minerals of economic importance, presents several interesting problems: among them being the determination of the age of the limestones, shales, etc., which form the basal portion of the Palæozoic column, and rest upon the old Pre-Cambrian rocks, and the tracing and correlation of the abandoned shore-lines of the ancient great lakes. On account of the difficulty of carrying on geological and topographical work at the same time, the geological work has suffered somewhat, and is not complete. The present report serves merely to draw attention to some points in connexion with the general geology of the district, which seem to be of especial interest.

The topographical work was carried on by means of plane-table traverses, elevations being determined by instrumental levels and by aneroid. The plane-table sheets were completed in the field; and control for the sheets was supplied by transit and chain traverses run by Mr. Owen O'Sullivan of this Survey.

Field work lasted from June 4 until October 24, in which work the following assisted: Jas. Hill, M.A., B.Sc.; Bert. R. MacKay, B.Sc.; L. B. Adams; R. H. Blackwell, and R. A. Rogers.

### Location and Area.

During the past season the topographical work on three '15'' sheets—to be known as the Barrie, Orillia, and Mud Lake sheets—was completed, and these sheets will be published on a scale of 1 mile to the inch, or 1/62500. The three sheets are bounded, respectively, by latitudes 44° 15′, and 44° 30′, and longitudes 79° 30′, and 79° 45′; latitudes 44° 30′, and 44° 45′, and longitudes 79° 15′, and 79° 30′; and latitudes 44° 30′, and 44° 45′, and longitudes 79° 00′, and 79° 15′.

### Previous Work.

The previous work of the Geological Survey in the Simcoe district of Ontario was done by Mr. Alexander Murray in 1852 and 1853, the results of which are given in Geology of Canada, 1863. Since that time numerous papers, by various writers, have been published: dealing chiefly with the glacial and post-glacial history of the district. Some time was spent last year by Messrs. Taylor and Goldthwait, and the writer, in an investigation of the Pleistocene geology of the district, and a short account of their work was given in the Summary Report for 1908.

## Summary and Conclusion.

The examination of the solid rocks of the district has shown that the following formations are represented: Trenton, Black River, Lowville (Birdseye), and Laurentian granites and gneisses.

The age of the limestones, which have been referred to the Lowville formation, has long been in question. These limestones are regarded as belonging to the Lowville formation, from the evidence of the fossils collected from the vicinity of Lake St. John, Ont., which were determined by Mr. E. O. Ulrich of the United States Geological Survey to be all Lowville species. This formation is widespread and well represented in northwestern New York and Pennsylvania, and as far south as Kentucky and Tennessee; and the wide acquaintance of Mr. Ulrich with the palæontology of the Ordovician formations of the United States makes his determination authoritative.

At the base of the Lowville limestone there are generally from 10 to 20 feet of shales, sandstone, and arkose, which are regarded as probably forming the basal arenaceous member of the Lowville formation. They appear to be perfectly conformable with the overlying limestone; also, just such deposits would be expected whatever formation first overlaps the old land. However, on account of the absence of fossil evidence the age of these deposits is uncertain.

In connexion with the Pleistocene geology of the district, it may be stated that, no definite raised beaches or abandoned shore-lines could be found above the Algonquin beach, at least up to an elevation of 250 feet above the latter.

## General Character of the District.

Over much of the district there is a heavy mantle of drift which is often of considerable thickness. Within the limits of the Barrie 15′ sheet no solid rocks are known to be exposed, and over the greater part of the sheet the drift is at least 200 feet thick; while in the northwest corner, where morainic hills rise to an elevation of over 400 feet above Lake Simcoe, it is probably much thicker. Within the Orillia and Mud Lake sheets, the drift is much thinner, and the Trenton, Black River, and Lowville limestones are often well exposed. The limestones generally form a low escarpment near the contact with the Pre-Cambrian rocks, which occupy small areas in the northern part of the sheets. Several outliers of Black River and Lowville limestone, surrounded by Pre-Cambrian rocks, occur in front of the escarpment, and sometimes at a considerable distance from it.

### GENERAL GEOLOGY.

The geological formations represented in the district may be summarized as follows:—

*Recent*—

Humus, sand dunes, marls, etc.

*Pleistocene*—

(1) Raised beaches, fluviatile and lacustrine sands, gravels, and clays.
(2) Glacial clays, boulder clays, and sands; fluvio-glacial sands and gravels.
(3) Sands, silts, gravels, and clay generally stratified.
(4) Till, or boulder clay.

*Ordovician—*

Trenton.

Black River.

Lowville (Birdseye), including an unfossiliferous basal member of shales, sandstone, and arkose?

*Pre-Cambrian—*

Laurentian granites and granite gneisses.

## Description of Formations.

*The Lowville (Birdseye) Formation.*—The most important point to be determined in connexion with the geology of the solid rocks of the district is the age of the basal members of the Palæozoic series of limestones, shales, etc., which rest unconformably upon the Pre-Cambrian rocks. The series includes upwards of 100 feet of limestones, shales, sandstone, and arkose, lying immediately below the Black River limestone. The difficulty in determining the age of these beds has been mainly owing to the fact that, they could not be definitely correlated with any of the known formations of the Ottawa or Champlain basins. The Trenton and Black River limestones are well represented in the Ottawa and Champlain basins, and continue westward into western Ontario and northwestern New York. In the Ottawa valley, at the base of the Black River limestone, there are a few feet of dove-coloured limestone which was formerly referred to the Birdseye, but lately has been generally included in the Black River. The dove-coloured limestone contains comparatively few fossils, and passes downward into the Chazy limestone characterized by a definite set of fossils. A similar succession of formations is found in the Champlain valley. As pointed out in the Summary Report for last year, it seemed possible that, in the portion of Ontario lying west of the Frontenac axis of Pre-Cambrian rocks, different conditions of sedimentation existed immediately preceding the deposition of the Black River limestone, and that the limestones, shales, etc., lying below the Black River limestone in that part of Ontario, could be more readily correlated with some one or more of the formations of the western basin. This correlation has been rendered possible by the work of Messrs. Cushing, Ulrich, and Ruedemann, in northwestern New York. In this district the first formation below the Black River is the Lowville (Birdseye): regarding which Mr. Cushing says:—[1]

'The Lowville limestone, while typically developed on the south and west side of the region, is but thinly developed in the Champlain valley, and is not sharply delimited from the formation above or below, as in the Mohawk and Black River valleys.'

Last year a small collection of fossils was obtained from the lowest fossiliferous limestones of the vicinity of Lake St. John, Ontario, and sent to Mr. E. O. Ulrich of the United States Geological Survey. The fossils were collected partly from the beds immediately underlying the Black River limestone and partly from fossiliferous beds, 30 to 40 feet lower down, and they are all, according to Mr. Ulrich, fossils of the Lowville formation. It may be stated here that the fossil described in the Summary Report for 1908, as *Tetradium fibratum*, and as occurring at the base of the Black River limestone in the Lake St. John section, was identified by Mr. Ulrich as *Tetradium cellulosum*—a characteristic fossil of the Lowville formation. *Tetradium fibratum* occurs higher up, in the beds referred to the Black River.

It would, therefore, appear certain that, these limestones should be referred to the Lowville (Birdseye) formation, and that they represent a formation which was well developed in the western basin but thinly developed in the Ottawa and Cham-

[1] Bulletin of the Geological Society of America, Vol. XIX, p. 172.

plain basins. In northwestern New York, the Lowville passes downward into a formation which Mr. Cushing has provisionally named the Pamelia, and which he regards as equivalent to the Chazy but deposited in an entirely separate basin. This formation, according to Mr. Cushing, also occurs in the vicinity of Kingston, Ontario; but no evidence has as yet been found of its extension westward into the Simcoe district of Ontario.

The Lowville limestones of the Simcoe district become arenaceous and impure toward the base, and pass downward, without apparent break, into red and green calcareous and arenaceous shales, with interstratified beds or lenses of coarse sandstone, and occasional beds of comparatively pure limestone. At the contact with the Pre-Cambrian rocks there are generally a few feet of coarse, calcareous grit or arkose containing many angular and sub-angular fragments of the immediately underlying crystalline rocks. The whole series has a maximum thickness of about 25 feet in the sections exposed in the Simcoe district. There is little definite evidence on account of the absence of fossils as to the age of this series of shales, sandstone, etc., but it is regarded as probably, the basal arenaceous member of the Lowville formation, for the following reasons:—

Just such sediments would be expected at the base of whatever formation first overlaps the old Pre-Cambrian land.

The series is apparently conformable with the overlying Lowville limestone, and occasional beds of comparatively pure limestone, apparently similar to the Lowville limestone, are interstratified with the arenaceous beds.

The arenaceous beds are local in character and distribution, and are frequently absent on ridges and knobs of the crystalline rocks, where the Lowville or Black River limestones rest directly on the old surface.

## Pleistocene.

*Algonquin Beach.*—During the past season, the Algonquin beach was traced northward from Kirkfield, Ont., to Uphill, and instrumentally levelled at a number of localities. The beach is well developed, and can be readily traced as far as the outlier of Lowville limestone at Uphill. On lot 11, concession IX, of Carden township, the elevation of the beach is 894 feet above sea-level; one mile east of Carden post-office, its elevation is 907 feet, and one-half mile north of Uphill post-office, 923 feet. This gives a tilt rate of very nearly 4 feet per mile, from Kirkfield to Uphill, in the direction of maximum uplift. Northward from Uphill the country is low for several miles, but northeastward, in Digby township, granite hills rise above the supposed level of the beach. It would be difficult, however, and no effort has been made, to trace the beach in that direction, as there is little drift covering, and the waves of Lake Algonquin left little impression on the bare rocks.

*Reported Higher Beaches.*—The occurrence of raised beaches or abandoned shorelines higher than the Algonquin, in the Lake Simcoe district, has been reported from time to time.

A favourable locality for the examination of the higher levels, up to 250 feet above the Algonquin beach, is the district lying south of Allandale, Ont.; where there is a heavy mantle of drift which has suffered comparatively little erosion. In the vicinity of Holly and Thornton, the drift forms a plateau-like upland, the general level of which is about 300 feet above Lake Simcoe.

In carrying on the topographical work in this area, instrumental levels were obtained over most of the roads, and an opportunity was afforded of determining the elevation of all land forms which bore a resemblance to beach markings or deposits. Numerous broad, flattened, kame-like deposits of stratified sand and gravel occur at various levels above the Algonquin beach up to an elevation of 1,025 feet above sea-

level; but these deposits are generally lacking in any definite horizontality or accordance of levels, and no cuttings were seen from which such deposits could have been derived by wave action or shore currents. Hence, such deposits are regarded rather as a product of fluvio-glacial action. It is possible that faint beach markings of local glacial lakes may occur, but none were seen that could be traced for any distance.

## ECONOMIC GEOLOGY.

The Black River limestones of the district are used most extensively for the manufacture of lime, and the Lowville limestones furnish the best building stone. The latter are extensively worked at the Longford quarries, on the west side of Lake St. John, in Rama township; and similar beds of limestone with little over-burden, outcrop in the vicinity of Sebright, Ont., and for several miles westward, where they could be easily worked.

## APPENDIX.

Since going to press, a report has been received from Mr. E. O. Ulrich, of the United States Geological Survey, on a collection of fossils obtained by the writer from the supposed Black River and Lowville limestones of the vicinity of Lake Couchiching, Ontario. Mr. Ulrich concludes, from an examination of the fossils, that the true Black River limestone as defined by the early New York State geologists is not present, or at least not recognizable in south-central Ontario, and that the cherty beds which have been included in the Black River formation should rather be given a distinct name derived from some locality in the district, considering: (1) 'that the stratigraphic and faunal break between the cherty zone and the 7 ft. tier (the true Black River) deserves recognition in stratigraphic classification; (2) that the Lowville formation as now fixed should not include the cherty bed.'

To meet this objection of including the cherty beds in the Black River formation, Messrs. Cushing and Ruedemann, in a communication to the Director of this Survey, propose to refer all the beds between the base of the Trenton and the Pamelia of Stones River (Chazy) age to the Black River group, including the cherty beds in the Lowville formation, under a distinct local name. This question in its relationship to the formations of south-central Ontario will be taken up more fully in the final report on the district.

The following is a list of the fossils:—

(1) *Lower Middle Lowville.*—

The fossils were obtained from a small quarry in North Orillia township, Ontario, 3 miles west of Washago. The beds from which the fossils were collected are about 10 feet in thickness, and constitute the lowest fossiliferous limestones seen in the district, and are separated from the red and green shales, which form the base of the section, by only a few feet of impure limestone:—

*Refinesquina minnesotensis.*
*Cyrtodonta*, n. sp.? closely allied to *C. janesvillensis* and *C. huronensis.*
*C. sillimanensis?*
*Vanuxemia rotundata.*
*Pterotheca attenuata.*
*Pterotheca*, sp. undet.
*Helicotoma*, n. sp.
*Liospira progne.*
*Liospira vitruvia.*
*Eotomaria vicinus.*

*Clathrospira subconica.*
*Lophospira concinnula*, var.
*Holopea*, cf. *concinnula.*
*Subulites*, n. sp. (near *S. regularis*).
*Cameroceras*, sp. undet.
*Orthoceras*, cf. *recticamerata.*
*Isotelus*, cf. *obtusus.*

(2) *Upper Lowville.*—

Fossils obtained in North Orillia township, Ontario, from beds which are about 20 feet in thickness, and are about 40 feet higher up in the section:—

*Tetradium cellulosum.*
*Ctenodonta*, cf. *gibberula.*
*Liospira*, sp. undet.
*Hormotoma angustata.*
*Trochonema*, sp. undet.
*Orthoceras*, near *O. recticameratum.*
*Cycloceras*, sp. nov. (near *O. perroti*, Clarke).
*Isochilina armata.*

(3) Suggested new formation, which Cushing and Ruedemann propose to include in the Lowville under the name of the Leray limestone member.

Fossils obtained in North Orillia township, Ontario, from the cherty beds, which are about 20 feet in thickness, and immediately overlie the beds of the upper Lowville:—

*Girvanella*, sp.
*Columnaria halli.*
*Tetradium fibratum.*
*Streptelasma profundum?*
*Beatricea gracilis.*
*Escharopora subrecta?*
*Nicholsonella*, cf. *laminata* and *cumulata.*
*Strophomena filitexta*, var.
*Refinesquina minnesotensis?*
*Orthis tricenaria.*
*Camerella panderi*, var. nov.
*Ctenodonta*, cf, *logani.*
*Ctenodonta*, cf. *scofieldi.*
*Helicotoma planulata.*
*Lophospira*, sp. undet.
*Hormotoma salteri canadensis.*
*Orthoceras*, small, pencil size.
*Orthoceras*, large species, externally resembling *Ormoceras tenuifilum.*
*Actinoceras*, sp, undet.
*Cycloceras*, sp. undet.
*Cycloceras? arenoliratum.*

# FIELD STUDIES ON THE PLEISTOCENE DEPOSITS OF SOUTHWESTERN ONTARIO.

*(F. B. Taylor.)*

Work was begun at St. Marys, Perth county, Ontario, on October 7, and closed at Tillsonburg, Oxford county, Ontario, on November 6. The plan of spending two, or two and one-half months on this work was unavoidably shortened to one month. The first three weeks were spent in studying the glacial features and deposits of the central part of the peninsula, in an area running north and northeast from Lucan and St. Marys to Mount Forest and Orangeville. The remaining time was given to studies near Dunnville, Caledonia, Hagersville, Simcoe, and Tillsonburg, collecting further details where earlier independent studies had been made.

## The Glacial Features of the Central Plain.

*Terminal Moraines of the Lake Huron Ice Lobe.*—In studies made before 1908, four terminal moraines were mapped for short distances across the western and northwestern part of the township of London, in Middlesex county. These moraines are slender and lightly formed, but are clearly defined as topographic features, and are easily traced. They are simple ridges of stony clay with only one crest, and are generally a mile or less in width. The height of the crest above the adjacent plain varies from 15 or 20 feet, to 70 or 80 feet; though seldom rising above 40 or 50 feet.

In western London township, these ridges run nearly north and south. One passes through Ettrick, to the Thames river 2 miles east of Melrose; another runs through Lobo and Telfer, half a mile east of Ilderton; another runs close west of Vanneck, one mile east of Denfield, and through Lucan; and another runs through Duncrief, just west of Denfield and one mile west of Lucan crossing. From these fragments previously mapped, the studies of the present season were carried north and northeast.

All four of these terminal moraines belong to the Lake Huron lobe of the ice sheet: i.e., they were made at the ice margin by ice moving toward the east and southeast from the central axis of the Lake Huron basin. The most easterly ridge of the four was, therefore, made first, the first one west of this was the next in order of formation, and so on. These four moraines, with the intervening till plains, glacial border drainage lines, and glacio-fluvial deposits were studied, in considerable detail, up to Seaforth, Mitchell, and Stratford.

In the vicinity of Denfield the four moraines are set close together, the distance across the series from east to west being not over 5 miles. This is because they lie upon land that slopes rapidly down to the west, so that the ice was advancing up the slope during the oscillations of its retreating phase. Going north, the moraines rise gradually to the flat, central plain, and spread between Walton and Milverton to over four times the space at Denfield. The moraines themselves are no wider or larger, but they are spaced with wider stretches of till plain between them. In view of their sharply-defined and continuous character as ridges running for many miles across the country, I have, as a matter of temporary convenience, adopted names for these four moraines. The first, which is the one that passes through Ettrick at the south, also passes through Milverton, and is called the Milverton moraine; the second passes just west of Mitchell, and is called the Mitchell moraine; the third passes through Lucan, and is called the Lucan moraine, and the fourth passes through Seaforth, and is called the Seaforth moraine.

*The Interlobate Area.*—The work from St. Marys and Stratford shows that the country for at least 15 to 20 miles east of the Milverton moraine is an interlobate plain, with no simple terminal moraines in it; but with several pronounced but rather small interlobate morainic areas. One of these—the only one which was examined—lies north of Shakespeare, in North Easthope. This is a characteristic interlobate deposit, higher than an ordinary terminal moraine, and with prominent knob and basin development. Many kames and other glacio-fluvial deposits are associated with it. Beginning one mile east of Brocksden, this deposit extends toward the northeast, with a width of 2 or 3 miles, and appears to extend into the northwest part of Wilmot township, though it was not followed beyond 2 miles east of Amulree.

*The Milverton Moraine.*—The desirability of completing the definition of the western border of the interlobate area, and the shortness of time remaining for field work, led me to drop for the time the detailed work on the three later moraines, and push the study of the Milverton moraine.

From a point about 2 miles west of Hyde Park, where this moraine meets the Thames river, it takes a fairly direct course toward the north-northeast, and was traced continuously to a point near Conn, about 10 miles east of Mount Forest, a total distance of about 80 miles on a straight line. In the last 10 or 15 miles the moraine loses much of its strength, and was quite difficult to follow beyond Riverstown. Although its course is in a fairly direct line, its deviations show three distinct but faintly developed lobes projecting eastward, with rather sharp re-entrant angles between. So far as they were followed the Mitchell, Lucan, and Seaforth moraines appear to show less tendency to the development of lobes.

*Till Plains.*—Throughout much of this area the till plains which lie between the moraines and east of the Milverton moraine are excellent examples of their class. To the eye they appear as flat as the ocean in a time of calm. Such are the stretches north of Stratford and east, west, and southwest of Milverton. It might be thought that these areas are floored with lake clays, but the evidence seen was against this view. The clays did not appear to be laminated, though sometimes showing obscure bedding planes, like those occasionally found in true till. In some places stones and pebbles were very scarce, but they appeared to be always present in small quantities. These characters are clearly distinguished from those of true lake clays such as cover the country in some other parts of the peninsula: notably, those at Schomberg, and between Caledonia and Hagersville.

*Moraines on the East Side of the Interlobate Area.*—Some strongly developed morainic deposits were found between Arthur and Alma, but their character and relations were not fully made out. Just east of Orangeville junction, crossing the railway from the north and turning west so as to pass 2 or 3 miles south of Waldemar, a very strong terminal moraine was found which belongs to the Lake Ontario lobe of the ice sheet. This moraine was, therefore, made at the margin of ice moving up the slope from the east and southeast. It seems quite certain that this moraine forms a part of the eastern boundary of the interlobate area, and probably includes the morainic fragment near Alma. Studies made several years ago disclosed a great terminal moraine running north from Ayr and swinging in a broad curve to the west so as to pass close west of Berlin and Waterloo; thence it runs west to Bamberg, where it turns to the north. This Waterloo moraine, as it is called, belongs to the Lake Ontario lobe, and appears to be another fragment of the eastern boundary of the interlobate area. In the northern part of the city of London a low morainic ridge trends east and west, and may be another fragment of the same. Excepting these fragments, the eastern boundary of the interlobate area has not yet been worked out. The moraines east of the Waterloo, however, were mapped in considerable detail in 1899.

It seems probable that the interlobate area extends to a point 5 or 10 miles northeast of Dundalk, thus having a total length of about 100 miles. The Milverton moraine, so far as it has been traced, sharply defined its western boundary, and it seems probable, though it is not yet certain, that the Milverton and Waterloo moraines were made at the same time.

*Ice Border Drainage Systems.*—The drainage systems developed in the interlobate area and along the front of the ice at the successive halts on the above-mentioned moraines, are well developed, but rather complicated. In some places they are quite striking, as at St. Marys, where gravel terraces distinctly above the modern flood plain record the former greater stream. There were many shiftings of drainage lines as the ice front retreated. For instance, when the ice rested on the Milverton moraine, a stream of considerable volume came from the northeast past Amulree and Brocksden and down the Avon. From St. Marys it followed the Thames to London. But at the next halt of the ice (on the Mitchell moraine) this stream abandoned the Thames at a point about 5 miles west of St. Marys, passed through to the rear side of the Milverton moraine, north of Prospect Hill, south of Granton, just north of Elginfield and west of Southgate, and on down Oxbow creek. This is a splendid specimen of an abandoned river bed occupied only temporarily. South of Granton it is a flat, swampy floor about one-third of a mile wide, and is not now occupied by any stream.

*Glacio-fluvial Deposits.*—Asociated with the moraines, many kames and kame-like gravel deposits were found, due evidently to waters issuing from dirty ice. In several places eskers or serpentine kames were found, well developed. South of Blyth there is a remarkable area of eskers running up the slope eastward and ending mostly in kame clusters of very pronounced development. The most remarkable individual esker observed extends for about 10 miles toward the southeast from a point 2 miles east of Mount Forest. The end of this ridge was not determined in either direction, and it may be much longer. It seems to record a time when the ice was very thin over the central area of the peninsula. Many other shorter fragments were found.

*Some Events of Glacial History in the Central Part of the Peninsula.*—The history revealed by these formations is an interesting one from the point of view of the influence of land relief upon ice movements. At its maximum extent the ice sheet no doubt covered this entire region to a depth of several hundred feet, but even then the lines of strongest ice flow were determined by the position and trend of the relatively deep basins of the Great Lakes, and the flow was less rapid over areas of high land. This effect upon the ice flow caused the surface of the ice, even at its greatest extent, to be higher along the axes of the lake basins than over the intervening areas of high land, and there was, in consequence, a depression in the surface of the ice over the latter. This was true even before any part of the land of this peninsula was uncovered. Thus, with the continued recession of the ice sheet the covering of ice over the high ground became progressively thinner, until it finally parted and drew back on both sides, leaving bare the interlobate area which these studies have disclosed. At the first halt of the ice front after the uncovering of the interlobate area, the front rested on the Milverton moraine on the west side and probably on the Waterloo moraine on the east. At a point 5 or 6 miles west of London, the Milverton moraine coming from the north unites with the London (Waterloo?) moraine coming from the east, indicating coalescence of the ice of the Huron and Erie ice lobes, one moving toward the southeast from Lake Huron, the other toward the northwest from Lake Erie. From this point the two ice lobes were undoubtedly united at this stage of retreat for at least 100 miles or more toward the southwest. Thus, at its first appearance the interlobate area terminated at the south-

west, where the two moraines now meet west of London. But, although the two ice lobes coalesced, the surface of the ice must still have remained lower along the line of contact than along the axes of the two lake basins. Hence, there was in all probability a wide, shallow depression or crease along the line of contact. In times of melting, this crease must have carried a great amount of water derived from melting over a vast extent of the ice sheet, and this occurred both before and after the uncovering of the interlobate area described above. It is interesting to note that there are features in eastern Indiana and northwestern Ohio which are almost certainly referable to the great glacial Crease river which came from the interlobate depression in Ontario, and that these features do not appear to be otherwise explainable.

## Notes on Glacial and Lake Features Between Dunnville and Tillsonburg.

The region between Dunnville, Caledonia, and Simcoe is one in which terminal moraines have not yet been found with certainty. Whether this is due in reality to their absence or to extreme faintness of expression because of deposition by ice standing in deep water, has not yet been determined. Some fragments of doubtful origin that were found in this area may turn out to be waterlaid moraines, but further study in the field will be necessary to determine their character.

A new area of drumlins was found on the plain north of Hagersville. They are of the long, narrow type and are very well formed with axes running S 70° or 75° W. They rise out of an extensive bed of lake clays, laminated and without pebbles. The drumlins themselves are quite bouldery, so much so as to suggest that they may have been washed to some extent by waves.

The strong moraine which passes just east of Waterford and Simcoe was found to extend a little west of south toward Normandale. The plain reaching some miles north and east from Port Dover is remarkable for its flatness. It appears, however, to be composed of till with some stones, and with little or no lake clay upon it.

A strong terminal moraine belonging to the Lake Erie ice lobe, and hence made by ice moving toward the north, was found running east from Tillsonburg, passing just north of Cornell and a mile south of Otterville. What appears to be this same moraine runs west from Tillsonburg, passing just north of Delmer, Brownsville, and Springfield. A fragment of another strong high moraine of the Lake Erie lobe was seen at Mount Elgin, with northeast and southwest trend. A well marked line of glacial border drainage coming from the east breaks through the Tillsonburg moraine a mile north of the town. For 10 miles or more east of Tillsonburg the country south of the moraine is covered with fine sand, apparently marking a former lake border, but no well-defined beach was observed here. Near Courtland, however, farther south and at a lower level, there are some sandy beach ridges.

# THE FLORENCE LAKE. AND MONTREAL RIVER DISTRICTS.

*(W. H. Collins.)*

## INTRODUCTION.

The geological exploration of the Montreal River district, begun in 1908, was continued during the past summer. The silver-bearing areas of James township and Maple mountain were explored for the Bureau of Mines in 1907 by Mr. C. W. Knight. In 1908, this work was continued by Mr. A. G. Burrows in the Miller Lake area. These, and the area covered by the writer in 1908, although almost identical in geological character, remained isolated. In order to establish a direct relationship between these separate areas, attention was directed, this year, to the unexplored intervals, especially those between Montreal river and its East branch. Meanwhile, Mr. Burrows of the Bureau of Mines, continued his detailed work in the vicinity of Gowganda, covering Van Hise, Haultain, Milner, Nicol, Leith, and Charters townships. Sufficient information has now been obtained, collectively, to map a continuous area of 900 square miles: which includes Elk Lake, Silver Lake, Miller Lake, Gowganda, and Maple Mountain mineralized areas. In addition, 40 square miles around Florence lake, which had attracted the attention of prospectors during the summer, were explored.

Work was carried on between May 28 and September 28. In connexion with the areal geology, micrometer-compass surveys were made along lakes and navigable streams. A partial system of hand-levels was also carried from the Timiskaming and Northern Ontario railway at Latchford, along Montreal and Lady Evelyn rivers. Both Montreal and Lady Evelyn rivers are sluggish streams with almost negligible gradients, or form chains of lake expansions separated by falls and rapids. By levelling over these obstructions and the watershed which separates the two streams near Smoothwater lake, and elsewhere estimating the gentle gradient, a closed circuit was obtained in which the error for any elevation is probably less than 3 feet. Aneroid determinations of hills and remote lakes are based on this series of levels.

The satisfactory progress of the work was due, in no small measure, to the assistants of the party: Messrs. H. C. Cooke, J. D. Trueman, and J. R. Marshall. Co-operation with Messrs. A. G. Burrows and W. R. Rogers, who represented the Ontario Bureau of Mines, also proved advantageous; while from mine officials and the people of the district a frank, courteous treatment was almost invariably received.

## FLORENCE LAKE DISTRICT.

### Access.

Florence lake—a headwater of Lady Evelyn river, lying 35 miles west of Latchford—is most easily reached from Timagami or Latchford station, on the Timiskaming and Northern Ontario railway. From Latchford, Montreal River steamboats may be taken as far as Mattawapika falls, but beyond that point Lady Evelyn river must be ascended in canoes. The whole distance is only 65 miles, but travel on the Lady Evelyn is rendered arduous by numerous and difficult portages. From Timagami lake, steamers may be utilized for about one-third the distance. Details of both routes are shown on the Timiskaming map-sheet published by the Department of the Interior, Ottawa.

### General Character.

Florence lake is an irregular body of beautifully clear water, 6 miles in length, lying 1,190 feet above sea-level. Its shores are for the most part bold and rocky, and for 3 miles inland in any direction—except to the north, where the ground is swampy—the country rises in bare, rounded hills to heights of from 200 feet to 550 feet above the lake. As a rule, soil is scanty, but near the outlet the rocks are covered by a heavy mantle of glacial sand. Timber is abundant and of good size. Lake trout are plentiful.

### General Geology.

The geology of the district is simple: a quartzite of Huronian age, traversed by sills and dikes of diabase, covers most of the area. The quartzite is a greyish or greenish-white rock, usually feldspathic, which frequently grades into arkose, or becomes finely conglomeratic. The bedding planes are indistinct, so that the rock has a massive appearance, and the dip and strike are seldom determinable. A few reliable observations of the dip indicate a gently undulating attitude, with a general southeasterly inclination. The diabase is quite similar to that found in the Montreal River district. It forms two sills and a number of dikes, of which only the sills are of economic interest. The smaller of these lies immediately southeast of Florence lake, the larger extends across it and, at the north end, spreads out irregularly. The diabase exhibits the usual fine-grained and gabbroid types, and ocasionally an acid, syenitic phase. It is cut by small aplite dikes and quartz-calcite veins. Movements, unimportant in extent, are indicated by the vein-filled fissures, and by local shear zones a few inches wide in the quartzite where the rock has been rendered schistose, with development of sericitic material.

### Economic Geology.

The quartz-calcite veins show the same structure as those in the Montreal River district, but were observed to carry only chalcopyrite, except at one point near the middle of Florence lake, where a trace of cobalt bloom was perceived. Many prospectors visited the district during the summer, though up to the middle of June apparently without success. Two of these, however, Messrs. Roy and English, state that native silver was discovered in August near the smaller diabase sill.

## MONTREAL RIVER DISTRICT.

### General Character.

As the work in the Montreal River district was an extension of that performed last year, it is only necessary to amplify the general topographical and geological accounts given in recent reports.[1] The area now explored, though presenting at all points the uneven, rocky surface characteristic of the Pre-Cambrian region, exhibits certain local differences, especially notable in the decreasing dip of the Huronian beds as one proceeds from west to east. In consequence of this, the parallel north-south, Huronian ridges, with steep western and gentle eastern slopes, which are such a constant feature in the vicinity of the West branch, become less conspicuous farther east, where the ridges run in various directions, and are partly replaced by hills of irregular, outlines. The townships of Farr, James, and Mickle, and most of the country to the south, are especially irregular. The central and eastern portions, which are heavily drift-covered in places, are not very rugged, the hills being mostly under

[1] Burrows, A. G., The Gowganda and Miller Lake Silver Areas. 18th Ann. Rep. Bureau of Mines, Pt. II.
Collins, W. H., Preliminary Report on Gowganda Mining Division. Geological Survey, 1909.

200 feet in height; but north and west of Duncan lake, and between Macobe and Lady Evelyn lakes on the southeast, the relief is greater. Maple mountain, in the latter locality, is approximately 2,000 feet above sea-level.

The above-mentioned topographical irregularity in the neighbourhood of Elk lake has evidently influenced Bear river and its branches, which ramify in various directions instead of pursuing parallel, zigzag courses like the East and West branches. All the branches are navigable in small canoes; but meandering courses and numerous shallow rapids greatly lessen their values as waterways. The North branch of the river flows through a soil-covered area, and is consequently almost devoid of the rocky lake expansions so common on the South branch, or the Sydney Creek system farther west.

## Access.

As roads continue to be opened through the country, canoe traffic is being gradualy superseded. A graded wagon road, 27 miles long, has been constructed by the Ontario government, between Gowganda and Elk Lake, with branches to Silver Lake, and Miller Lake mining camps, thus establishing communication with the Timiskaming and Northern Ontario railway at Charlton during winter, and with Latchford in summer. The Canadian Northern Railway extension from Sudbury is being continued, and before the end of the year will reach Oshawong lake (Gowganda Junction), about 45 miles southwest of Gowganda. A road now in preparation between these points will replace the Sellwood route used last winter. Short wagon roads have been constructed from Mountain lake to various mining camps in Willet township; from Lady Evelyn lake to the Maple Mountain camps; and elsewhere.

## General Geology.

For convenience, the general geological structure of the district is restated. An uneven, erosion floor of highly metamorphosed, crystalline rocks (Keewatin and Laurentian) is overlain by a series of comparatively unaltered, gently tilted sediments (Huronian). Both are penetrated by dikes and sills of diabase, and the whole so deeply denuded as to re-expose portions of the old crystalline basement. Glacial drift is spread unevenly over the solid rock surface.

In the area explored this summer, between Sydney creek and Montreal river, the Keewatin-Laurentian basement is entirely hidden by the Huronian, except to the north of the Stony Creek canoe route, whence granite and gneiss extend northward and westward. As these rocks are neither of special economic interest nor largely exposed, they need be given no further mention.

The Huronian is the most widely spread series. Structurally and in composition, it presents considerable contrast to that seen farther west in the vicinity of Duncan lake in 1908; a fairly steady variation in these respects being observable along a northwest-southeast line through the district. In the northwest, about Duncan lake, the series consists of conglomerate, greywacke, slate, and some quartzite, often complexly alternating, and always inclined to the east, at angles of from 15° to 45°. Toward the middle of the district, in Haultain and Lawson townships, the dip decreases to from 5° to 15°, and quartzite, with its arkose and conglomeratic varieties, becomes relatively abundant. Finally, the whole southern part as far as Lady Evelyn river is wholly underlain by these varieties, lying in low folds with dips of only a few degrees. It is possible that the quartzite stands high in the series, and that its wide distribution in the south is due to the greater thickness of the Huronian in that region; but at Gowganda, Duncan lake, and elsewhere, quartzite occurs near the base of the series, and appears, in part at least, to displace rather than overlie the slate and greywacke.

The continued examination of the diabase masses proves them to be either dikes or sills. The former, which are very numerous, appear to have been the vents through

which the sill-forming material arose. Though in many cases attaining widths of a hundred feet, they are of no economic interest. The sills are associated with the Huronian series, beneath or within which they have been intruded, and their attitudes appear to be controlled by the Huronian beds. In the west, where the Huronian is most inclined, the sills are also inclined, and outcrop only edgewise in narrow bands; while in the vicinity of Elk lake, where the Huronian is approximately flat-lying, erosion has exposed large, equidimensional patches of the equally flat-lying diabase. The Miller Lake and Gowganda sills are intermediate in this respect, exhibiting a general north-south elongation.

In addition to the region already mapped, considerable areas of diabase were found in Willet, Shillington, Trethewey, and Gamble townships. Olivine-diabase dikes similar to those observed last year were found at wide intervals over the entire district. They are distinguished from the commoner quartz-diabase dikes by conspicuous feldspar crystals, ranging up to 4 inches in diameter.

Over most of the district the covering of glacial sands and gravels is thin and sporadic. However, an extensive area, including most of Chown, and portions of Lawson, Mickle, and James townships is buried, in places to depths of a hundred feet. A smaller sandy area extends up the Montreal river from the one-and-a-half mile portage.

## Economic Geology.

Explorations in the Montreal River district sustain to a remarkable degree the idea of an intimate relationship between the quartz-diabase and the silver-cobalt vein deposits suggested by W. G. Miller, the provincial geologist, who studied the conditions existing at Cobalt. Throughout a mineralized region 80 miles in length these veins occur always within or in close proximity to the diabase. It is believed that the ores of silver, cobalt, and nickel which they carry were eliminated from the diabase magma in the form of a highly aqueous solution. The quartz which forms part of the gangue probably originated in the same manner, but there is reason to believe that the calcite, which is commonly a more abundant gangue mineral, was dissolved from other rocks—probably the Keewatin—to which the vein-filling solutions had access.

The known areal distribution of the silver-cobalt minerals has been extended during 1909. Silver was found about the end of June in the southeastern portion of Leith township, near Flanagan lake. According to Mr. Burrows, the geological features in this locality are identical with those of Gowganda; Huronian slate, greywacke, conglomerate, and quartzite being intruded by a sill and numerous dikes of diabase. Narrow calcite veins carry native silver, smaltite, niccolite, and native bismuth: good showings of which were seen on H.S. 693 and H.S. 716. Silver has also been found in Lawson township, along the north border of Willet township, and on the west side of the East branch a short distance south of Charters township. In addition, seemingly truthful reports of the occurrence of silver have been received from Shining-tree Lake district, and from Rosie creek, 15 miles farther south along the Algoma-Nipissing boundary line.

Discoveries, such as the Morrison vein 2 miles south of Miller lake, continue to be made in the Gowganda and Miller Lake areas as further surface exploration is prosecuted. When it is considered that certain Huronian areas, such as that lying northeast of Elkhorn lake, are probably underlain at no great depths by the intrusive sills, it would seem that attention has been too closely confined to the diabase. That mineralized veins do occur outside but near the diabase, is instanced by the Blackburn property near Miller lake, and the North American at Silver lake; in the latter case a silver-carrying vein passes from the diabase upward into quartzite.

Mining camps now exist at Elk lake, Silver lake, Miller lake, Gowganda, and Maple mountain, at each of which about the same amount of progress has been made

under nearly identical physical conditions. The Elk Lake and Silver Lake camps are somewhat older than the others, and have enjoyed better transportation facilities, but at present all of them are reasonably well connected. The more active mines in each camp are similarly equipped with boilers, air compressors of capacities up to 900 cubic feet, hoists, and air drills, besides suitable buildings for housing from 10 to 70 men. The amount of work performed with these plants since their installation varies greatly; in a few of the most progressive mines the underground work aggregates 800 feet in length, their shafts reaching depths of from 100 to 160 feet. Surface exploration is being actively continued. At Gowganda, progress of this description is being made on the Reeve-Dobie, Bartlett, Mann, and Boyd-Gordon properties; at Miller lake, on the Gates, Blackburn, and Bonsall, where, however, operations have been suspended; at Silver lake, on the Otisse, Otisse-Currie, and North American; at Elk lake, on the Elk Lake Discovery, Silver Alliance, Toledo, Gavin Hamilton, Moosehorn, Elk Lake, Cobalt, Big Six, and others; and at Maple mountain, on the White Reserve, and Maple Mountain properties. The Silver Lake Mining Company, at Silver lake, is exploring with a diamond drill. There are also other properties, too numerous to mention individually, where both underground and surface exploration is being performed without machinery.

As far as can be learned, a few tons, in one case seven, have been shipped by some of the working mines; but a majority of those above named have two carloads or less of rich ore, and larger quantities of low grade ready for shipment. Valuable ore was seen in place in the Maple Mountain, Gowganda, and Miller Lake districts, but estimates of the amounts available are only conjectural.

Underground exploration performed thus far in the Gowganda and Miller Lake districts indicates that the rich ore—the discovery of which at the surface created such high expectations—is irregularly distributed. A number of veins, the surface values of which were remarkably high, have become barren at moderate depths. This erratic occurrence of ore is being recognized, and hope is entertained of the existence of veins in which the mineralized portions lie wholly below the surface. Search for these is often facilitated by a parallel arrangement of the veins, so that trenching or cross-cutting at right angles to one will expose the others. Less is known about the Silver Lake and Elk Lake properties, but those visited do not appear to yield the rich masses seen elsewhere. At Maple mountain, some of the veins discovered on the surface have disappeared at a few feet down; but, in one case, good ore has been followed to a depth of 150 feet.

## Future Possibilities.

The outlook of the district, as inferred from recent work, appears to be satisfactory, although not equal to sanguine earlier expectations. Valuable discoveries, such as that on the Morrison property, which continue to be made within the limits of the mining camps, indicate how imperfectly known even the best explored localities are. Indeed, the advantage offered by an exposed, deeply-eroded rock surface, in the search for ore has been under-rated, effort being directed to the much costlier and but little more efficacious underground work rather than to trenching on the surface. The possibilities of the surrounding country, judging from the recent discoveries at Flanagan lake, Shining-tree lake, Willet township, and elsewhere, are not by any means exhausted, nor are the limits of the silver-bearing region known.

This widespread distribution offers serious disadvantages to economical mining. The ore bodies now known are large enough to be profitably operated, but, when these are exhausted, extensive explorations through barren rock will be necessary to locate new ones which may not reach the surface. By way of compensation, expenses in the Gowganda and Miller Lake camps should be reduced by the improved roads that will be opened for traffic this winter.

# LARDER LAKE AND EASTWARD.

*(Morley E. Wilson.)*

## INTRODUCTION.

The field season of 1909 was spent by the writer in extending the geological investigations commenced in 1908 in the vicinity of Lake Opasatika, Pontiac county, Quebec, to Barrière and Kekeko lakes on the east, and across the interprovincial boundary to Larder lake, Ontario, on the west. By the completion of this work the necessary data have been procured for the publication of a geological map on the scale of 1 mile to 1 inch, of a district having an approximate area of 600 square miles: comprising the townships of McVittie, McGarry, Hearst, McFadden, Skead, and Rattray, in Ontario; and the townships of Dufay, Montbeillard, the southern parts of Dasserat and Boischatel, and the northern parts of Pontleroy and Desandrouins, in Quebec.

Although this region is intersected by a number of township lines surveyed by the Crown Lands Departments of Ontario and Quebec, very few of the numerous lakes and watercourses had been mapped with sufficient accuracy—if mapped at all—to warrant their use in a map of the proposed scale; it was, therefore, necessary to make surveys of all the hydrographic features of the region. During the past summer this part of the work was carried on by Mr. Robert Harvie, of McGill University; while the writer devoted his attention to the geological features of the district.

A number of geological reports have been published at various times on portions of the above area, but have all been of a reconnaissance or preliminary character. In 1872, Mr. Walter McOuat, in the course of an exploratory trip from Lake Timiskaming to Abitibi, made a geological examination of the shores of Lake Opasatika, an account of which appeared in the Report of the Geological Survey for 1872-3. During the summer of 1901, Dr. W. G. Miller, Provincial Geologist of Ontario, made a reconnaissance trip from Lake Timiskaming to the height of land, by way of the Blanche river and Windigo, Larder, and Beaverhouse lakes. His observations along the route were published in the Report of the Ontario Bureau of Mines for the year 1902. A geological reconnaissance of the country north of Lake Timiskaming was made for the Geological Survey by Dr. W. A. Parks, of Toronto University, in 1904. This work—an outline of which was published in the 1904 Summary Report of the Geological Survey—included the geological examination and survey of some of the principal waterways described below. In 1907, Mr. R. W. Brock made a geological report on the Larder Lake district for the Ontario Bureau of Mines. This report, however, was based on field work which occupied less than two weeks' time.

## TOPOGRAPHY.

The Larder Lake district, and the adjoining portions of Pontiac county, present the typical physical features which characterize the Pre-Cambrian of northern Ontario and Quebec. To the east of Lake Opasatika, a large clay area occurs, in which rock exposures are rarely observed. This comprises nearly the whole of Montbeillard township. In the southwestern part of the area mapped—Skead and Hearst townships—the rock surface is largely obscured by glacial sand and till. With the exception of the two localities just mentioned, the country is comparatively rocky, more especially so where the rugged ridges of Huronian rise to elevations of from 600 to 700 feet above the surrounding country.

Since nearly the whole of this region is on the south side of the height of land, the drainage is largely into Lake Timiskaming: in the eastern part by way of Rivière and Lac des Quinze; in the western by way of the Blanche river. There are, however, a few lakes at the northern extremity of the sheet, beyond the St. Lawrence-Hudson Bay divide, which drain into Island (Mattawagosik) lake, and thence to Lake Abitibi and James bay.

## GEOLOGY.

In a general way, the rocks of this area afford a very distinct record of geological events. At the base of the whole region is a complex group largely igneous, comprising the Laurentian and Keewatin, the members of which, although of different age, are all distinguished by their greatly disturbed and metamorphosed character. Resting unconformably on the uneven surface of this ancient complex is a series of but slightly disturbed Huronian sediments—conglomerate, greywacke, and arkose. These sediments—with the exception of a few local intrusives, which are post-Huronian in age—comprise the youngest rocks in the region; any sediments that may have been deposited between that time and the deposition of the glacial drift, having since been entirely removed by erosion.

The geological succession is outlined in detail in the following table:--

*Pleistocene and Recent*—
Post-glacial: clay, sand, and gravel.
Glacial: boulder clay, sand, and gravel.
Unconformity.

*Post-Huronian*—
Diabase, gabbro, porphyry, and lamprophyre.
Igneous contact.

*Huronian*—
Conglomerate.
Arkose.
Greywacke.
Conglomerate.
Unconformity.

*Laurentian*—
Granite, gneiss, pegmatite, and aplite.
Igneous contact.

*Keewatin*—
Quartz-porphyry and porphyrite
Rusty weathering carbonate rock.
Phyllite, slate, and greywacke.
Greenstone, and greenschist
(Pontiac schist.)[1]

### Keewatin.

The Keewatin series consists of a complex group of rocks, chiefly igneous, although containing some sediments, all of which have been greatly disturbed and more or less metamorphosed. These changes have beeen carried so far, in many cases, that it is exceedingly difficult to determine either their original character or structure.

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1 Placed provisionally in the Keewatin

*Pontiac Schist.*—To the east of Lake Opasatika an area of nearly 100 square miles is occupied by very uniform, fine-grained mica schists, which, in their mineralogical composition, correspond to metamorphosed quartzites and arkoses. They consist chiefly of quartz and biotite, with usually some feldspar, either orthoclase or albite. Owing to the widespread occurrence of this rock in Pontiac county, and the distinct characteristics which separate it from all the other rocks of the region, it has been given the local name, Pontiac schist.

With regard to the age of the Pontiac schist, two facts are known: it is overlain unconformably by the Huronian, and is intruded in a most complex manner over wide areas by Laurentian granite and gneiss. It forms, therefore, part of the great fundamental complex, which in this region suffered peneplanation during the long interval that elapsed prior to the deposition of the Huronian clastics. Since the nomenclature adopted by the International Committee for Lake Superior geology makes no provision for this rock, it should properly be regarded as a distinct, new series; but in the absence of more definite knowledge with regard to its age and importance, it has been placed provisionally in the Keewatin.

*Greenstone and Greenschist.*—By far the larger part of the Keewatin is made up of basic igneous rocks, which may be described in general as greenstones and greenschists. These include basalt, gabbro, diorite, and chlorite and hornblende schist. They generally contain a considerable quantity of pyrite and carbonate, and in many places show spheroidal and amygdaloidal structures.

*Phyllite, Slate, and Greywacke.*—On the north shore of Larder lake, there is a belt—nearly 1 mile wide—of interbanded phyllites, slates, and greywackes, which parallels the lake shore for several miles. These rocks have a nearly vertical attitude; a uniform northeasterly strike; are in places, graphitic; and locally contain small quantities of iron ore formation.

*Rusty Weathering Carbonate Rock.*—In the neighbourhood of Larder lake, and north of Lake Opasatika, are local outcrops and bands of a rusty weathering rock, consisting of ferruginous dolomite or ankerite, with varying quantities of quartz and feldspar. It is always highly pyritic, and in most localities contains a large amount of chrome mica or fuchsite, from which the rock derives its characteristic green colour. As a rule, the rock is cut in a most complex manner by two or more sets of veinlets consisting of quartz or of quartz and ferruginous dolomite, the dolomite occurring along the margin of the veinlet and the quartz in the centre. The fracturing to which these veinlets owe their origin has been carried so far in many places, as to convert the carbonate rock into a breccia.

Since the carbonate rock occurs, on the north shore of Larder lake, as bands in the slates, phyllites, and greywackes, it might be assumed that it owed its origin to sedimentary deposition in the same manner as the other rocks with which it is there associated. There is, however, an apparent relationship between this rock and the quartz-porphyry and porphyrite of the area which this hypothesis does not explain. In some places the carbonate rock forms well-defined bands within the porphyry, while in other places the two rocks appear to fade into one another. The veinlets of quartz and dolomite which cut the carbonate rock also occur in the porphyry. When examined under the microscope, the porphyry is generally found to contain a considerable amount of carbonate, which, from the brown colour of the weathered surface of the rock, is evidently ferruginous dolomite. In view of these complicated field relations, it has been thought advisable to postpone the further discussion of the origin of the rock until its chemical and petrographical study has been completed. This subject will be fully taken up in the final report on the district, which is now being prepared.

*Quartz Porphyry and Porphyrite.*—Widely distributed throughout the older Keewatin rocks of the Larder Lake district, and the adjoining portions of Pontiac county, are areas and dikes of intrusive quartz porphyry and porphyrite. In many localities this rock and the greenstone have been so intermingled that their separation on the map cannot be made except in a very approximate manner. It has even gone so far in some places as to produce a rock which on the weathered surface looks like a conglomerate, and hence might be described as autoclastic. The occurrence of dikes of the porphyry in the greenstone, however, seems to prove that it is the younger rock of the two.

### Huronian.

An approximately, regular succession can be recognized in the Huronian rocks of this district. At the base there is a conglomerate which passes gradually upward through greywacke into arkose, which in its turn grades into an upper conglomerate. These sediments have been very gently folded into northeasterly and southwesterly synclines and anticlines, the angle of dip averaging about 10°.

The character of the surface upon which the Huronian was deposited in this area was, evidently, not uniform. A very sharply-defined line of junction can be observed in some places; but in other localities, the underlying rock passes insensibly upward through greywacke or arkose into conglomerate. Where the former type of contact occurs, the pre-Huronian rock surface had undoubtedly been subjected to very active erosion; while in the latter case the conglomerate was apparently developed on a surface which had suffered mechanical disintegration to a great depth, but with very little accompanying chemical decomposition.

It will be observed that this series has not been assigned to any particular division of the Huronian, although it is, without doubt, equivalent to the rocks which, elsewhere in the Timiskaming area, have been called lower Huronian or lower and middle Huronian, as described by Dr. Miller in the Cobalt area There seems to be, however, a reasonable doubt as to whether the relationship of these rocks to the original Huronian of the north shore of Lake Huron is sufficiently well known to permit of such close correlation. In view of this fact they have been, here, described as simply Huronian.

*Post-Huronian Intrusives.*—The Huronian and older formations described above are intruded, locally, by a considerable variety of rocks: including diabase, olivine diabase, gabbro, porphyry, and lamprophyre. The diabase and gabbro intrusive usually differs from similar rocks occurring in the Keewatin, in its fresh, unaltered character and coarser texture. It has a close resemblance to similar rocks, in the Cobalt area, and is no doubt equivalent to them. To the east of the north end of Lake Opasatika, between Ollier and Renault lakes, the Huronian is cut by a dike of porphyry. It is probable, however, that this is simply an acid, porphyritic phase of the post-Huronian diabase and gabbro. The lamprophyre occurs, in a series of crumpled dikes cutting sheared conglomerate, on the shore of Larder lake, at Larder City.

## ECONOMIC GEOLOGY.

### Gold.

The auriferous deposits which have attracted attention in the Larder Lake district and adjacent portions of Pontiac county, during the last few years, may be grouped for the purpose of description into two classes:—

(1) Veinlets of quartz, or of quartz and ferruginous dolomite in carbonate rock and porphyry.

(2) Veins of quartz, or of quartz and calcite.

The first class of deposit is much the more important. The carbonate rock, which in a number of places has a width of 300 feet or more, is usually cut by veinlets of quartz, or of quartz and ferruginous dolomite, throughout nearly its whole mass; so that, although the veinlets are small and irregular, they occur over extensive areas. In several localities, to the northeast of Lake Opasatika and in the vicinity of Larder lake, this type of occurrence has furnished good specimens of free gold, which in some cases assayed from $1,000 to $3,000 to the ton. According to the report of Mr. Morley Ogilvie, who had charge of the mining operations of the Dr. Reddick Company in 1908, a mill run of 100 tons from an open-cut on the Knott claim (H.J.B. 29) yielded from $10 to $12 to the ton. During the winter of 1907, a shipment of 1,500 pounds from the Harris Maxwell sent to the mill at the School of Mining, Kingston, returned $13.20 per ton. On the other hand, during the past summer a run of 230 tons from the same open-cut on the Harris Maxwell averaged 45 cents per ton. Many of the quartz stringers, even where best developed, have been found from assays to contain little or no gold. Samples taken, at 6 inch intervals, across several open-cuts in some of the best showings of quartz in the district, contained only traces of gold when assayed by Mr. Leverin of the Mines Branch, Department of Mines. In one case, an assay of samples from a drift from which some of the best specimens the camp has produced were obtained, gave results of 20 cents in gold and 5 cents in silver to the ton.

The information obtained up to the present with regard to this type of deposit may be summarized as follows:—

(1) The gold values are confined almost entirely to the stringers of quartz, or of quartz and ferruginous dolomite.

(2) The veinlets of quartz, or of quartz and ferruginous dolomite, in many localities, contain no gold, or, if present, it is in insufficient quantities for profitable mining operations.

(3) Locally, this type of deposit carries average values in gold of from $3 to $10 or more to the ton; but in most cases, at least, the ore body is too small to be worked at a profit.

With regard to the future possibilities of some of these prospects, however, further development work and mill tests are required to prove their extent and average value. In the case of the Dr. Reddick, considerable work was accomplished in sinking and drifting on the Knott claim during the past summer, but the rock from these workings has not as yet been tested in the mill. As the surface showings of gold are probably as extensive on this claim as anywhere in the Larder Lake district, the operations now being carried on by the Dr. Reddick Company have a very important bearing on the future of Larder lake as a gold mining camp.

The second class of auriferous deposit has been found in nearly every geological formation of the region. They are usually well-defined veins, from a few inches to several feet in width, carrying small quantities of sulphides such as pyrite, chalcopyrite, galena, and blende, with gold values up to $2 or $3 per ton. The veins of this class occurring in the Keewatin are commonly irregular and of small linear extent; those found in the Huronian and Laurentian are more uniform and continuous.

### MINES AND PROSPECTS.

The following are a few of the more important gold prospects in the district:—

*Harris Maxwell.*—The Harris Maxwell Gold Mining Company holds two claims—H.S. 114, and H.S. 115—on the shore of Larder lake, about half a mile northeast of Larder City. Mining operations, however, have been confined entirely to H.S. 115, the greater part of which is occupied by a hill of siliceous carbonate rock, more or less cut by stringers of quartz and ferruginous dolomite. Rock has been milled from an open-cut on the top of this hill, from a cut on its northeasterly slope, and from a

tunnel about 80 feet in length which enters the hill on the eastern or lake shore side. The equipment on the property includes a stamp mill, and camp accommodation for about 20 men. Development work was begun on the Harris Maxwell in the winter of 1907, and carried on more or less continuously until the autumn of 1908, when the mill was closed down. In August, 1909, work on the property was resumed by the Lucky Boys Mining Company, operating under option, but was discontinued the latter part of September.

*Dr. Reddick.*—The property belonging to the Dr. Reddick Larder Lake Gold Mining Company, comprises a half dozen claims situated at the eastern extremity of the North East arm of Larder lake. Although some development work has been accomplished on nearly all of these, the more important operations have been confined to the Knott claim—H.J.B. 29—already referred to. The development work completed up to the present on this claim consists of a shaft 83 feet deep, 162 feet of drifting at the 83 ft. level, and numerous test pits and open-cuts, one of the latter being 10 feet wide, 50 feet long, and 15 feet deep. The mining plant installed on the property includes a 20 stamp mill, a compressor, one 80, and two 20 horse-power boilers. Only 10 of the 20 stamps, composing the mill, have been in actual operation, and those for only a very short period in the autumn of 1908. About 150 tons of ore were milled between the first of September and the middle of December of that year, but the work was greatly hampered by frequent breakdowns. Operations on the property since that time have been limited to development work, between 25 and 30 men being employed during the past summer for that purpose.

*Gold King.*—The Gold King claim—H.F. 140—occupies the eastern portion of the peninsula on Larder lake, to the east of Larder City. The greater part of the rock on the claim is Keewatin greenstone; but on its northern border near the lake shore, there is an area of porphyry cut by veinlets of quartz and ferruginous dolomite, which carry some visible gold. The work done on the claim consists of some stripping, a few small cuts, and a narrow tunnel 30 feet long.

*Tournenie.*—The Tournenie Mining Company owns a large number of claims in the vicinity of the north shore of Larder lake, including those which formerly belonged to the Larder Lake Proprietary. A stamp mill was erected on one of these claims (C.E. 33) in 1907 by the Proprietary Company, but has never been put into operation. During the summer of 1909, the Tournenie Company confined its efforts to developing its numerous claims sufficiently to comply with the government assessment requirements.

*Lincoln Nipissing.*—The most important claims owned by the Lincoln Nipissing Development Company are located on a northwesterly-southeasterly band of carbonate rock, which crosses the south half of lot 5, concession VI, Skead township. A very good camp building has been put up, and a boiler and hoist installed on claim C.E. 3. The depth of the shaft was not ascertained, being full of water when visited.

*Kerr Addison.*—The Kerr Addison claims adjoin the Reddick on the west, and hence are crossed by the same carbonate band as the Knott claim of the Reddick group. Development work has been confined to H.S. 166, and consists of some stripping, a few surface openings, and an adit tunnel 50 feet in length.

*Pontiac and Abitibi.*—The claims of the Pontiac and Abitibi Mining Company are located about 2 miles northeast of Lake Opasatika, along the north shore of Renault lake. A few test pits and one 30 ft. shaft have been sunk on the property, some of the former being in carbonate rock precisely similar to that on Larder lake. A winter road has been built from Renault lake to Lake Opasatika, and thence to the head of the northeast arm of Larder lake.

*Lucky Boys.*—A large number of claims in the district are owned by the Lucky Boys Gold Mining Company, but their chief development work has been confined to H.S. 184, and the Chesterville claim situated between H.J.B. 28 and H.J.B. 29 of the Reddick group. Two shafts have been sunk on the Chesterville claim and one on H.S. 184, the maximum depth being about 40 feet. There is also an adit tunnel about 40 feet in length, on H.S. 184, which has been driven into the hill side to connect with the bottom of the shaft.

## Silver.

There are two mineral occurrences in the district which may be mentioned under this head, one on B.G. 229, a claim belonging to the North Canadian Gold Mines Company, and the other on the Mageau claims, lot 12, concession V, Skead township. In the first locality, the deposit consists of irregular veins of galena, blende, and chalcopyrite, in Keewatin greenstone. One of these veins has a maximum width of about 10 inches, but pinches out quickly when followed along the strike. The galena is said to carry 60 ounces of silver to the ton. On the Mageau claims, veins of quartz and calcite occur cutting Keewatin greenstone, the calcite, in places, containing galena, blende, and cobalt bloom.

## Copper.

A few small deposits of quartz and sulphides of copper—chiefly chalcopyrite—have been located in the district, among which are those on the Copper Queen—H.S. 112; the Quinn claim, on Dushwah (Turtle) lake, and the Renault claim, north of Nabugushk lake. In the last mentioned locality small quantities of native copper have been found.

## Cobalt and Nickel.

Cobalt bloom has been mentioned above as occurring on the Mageau claims. Mr. Brock notes its occurrence also in a calcite stringer, on one of the Chesterville claims.

Small deposits of pyrrhotite are of frequent occurrence in the Pontiac schist, one of which, on the east shore of Lake Opasatika, was examined by Mr. McOuat in 1872. A sample was analysed by Mr. Hoffmann of this Survey, and found to contain traces of cobalt and nickel.

# SERPENTINE BELT OF SOUTHERN QUEBEC.

*(J. A. Dresser.)*

## INTRODUCTION.

In accordance with the Director's instructions, the past field season was spent in an examination of a portion of the serpentine belt of southern Quebec, between the St. Francis and Chaudière rivers. After a preliminary examination of a part of the county of Brome, where some prospecting for asbestos was being done, and a short visit to some of the asbestos prospects of northern Vermont, I was joined, on June 10, by Mr. A. MacLean, graduate student of Toronto University. Camp was made at convenient places in the district, and work was continued until October 24.

Using the Eastern Townships map—enlarged to a scale of 1 mile to 1 inch—for a topographical basis, the geological mapping was carried on principally by chain and compass surveys. Certain cross sections requiring greater precision were measured by transit and stadia. Material has now been obtained for a preliminary map of the serpentine areas thus far examined.

I am indebted to A. MacLean, B.A.—who acted as assistant for the third year—for most efficient services; to W. J. Messenger, M.A., for valuable temporary assistance; and to the managers of the various mines of the district for many courtesies.

Dr. C. H. Richardson, of the Geological Survey of Vermont, spent several days of his field work in showing me over a section across a part of that State. An opportunity was thus afforded of following the complicated structure of this region from Ordovician to Pre-Cambrian, including the serpentine belt, under most favourable conditions. I must acknowledge with warmest thanks Dr. Richardson's valuable aid and kindly courtesy.

## LOCATION AND AREA.

The area examined forms a narrow belt which extends from the St. Francis river in the county of Richmond to a point near the Chaudière river, in the county of Beauce. The northern extremity is near the town of Beauceville, on the Quebec Central railway, about 50 miles from Quebec city. Toward the south the work was carried to Corris station, on the Grand Trunk railway, 81 miles from Montreal, on the main line to Portland. The length of the area examined is about 80 miles, its greatest breadth 8 miles, and the average less than 2 miles.

## PREVIOUS WORK.

The first geological examination of this area was made by Sir William Logan, whose work was supplemented by chemical and mineralogical investigations by T. Sterry Hunt, principally between the years 1847 and 1863. The general distribution of the serpentines and associated rocks was ascertained, and their economic importance pointed out.

In the Report of Progress of the Geological Survey for 1880-1-2, Dr. F. D. Adams published the results of a microscopic examination of a suite of specimens of these rocks, and showed that the serpentines are derived by alteration from peridotite, an igneous rock, and not from sediments as had been previously supposed.

Between the years of 1883 and 1886, soon after the beginning of asbestos mining in the district, a re-examination was made by Mr. R. W. Ells, who carried out an extensive revision of the areal geology of the southern part of the Province of Quebec.

In 1905, a monograph by Fritz Cirkel, M.E., was issued by the Mines Branch of the Department of the Interior, which describes the occurrence, uses, and methods of mining and concentrating asbestos. In 1908, a similar volume on the subject of chromite, also by Mr. Cirkel, was issued by the Mines Branch of the Department of Mines.

In 1907, a detailed examination of the serpentine belt was begun for the Geological Survey by the writer, and in 1909 a short paper on the mode of occurrence of asbestos was published in *Economic Geology*, and a somewhat more general one on the mineral resources of the serpentine belt, in the Journal of the Canadian Mining Institute.

## OBJECT OF THE PRESENT INVESTIGATION.

The present investigation, which was begun in 1907, was designed to obtain the fullest information possible regarding the geological structure and economic resources of the serpentine belt, with especial reference to the asbestos and chromite deposits. Accordingly, the work of the first season, which was a short one, was principally spent in a study of the character and mode of occurrence of the mineral deposits themselves, and was confined to the mines and their immediate vicinity. The work was suspended during the following year, but was resumed in 1909, when a study was made of the distribution and extent of the mineral-bearing rocks and of the geological features which govern the occurrence of the mineral deposits.

The work is now so far advanced as to permit of issuing a preliminary report and map of the portion of the district which lies between the Chaudière and St. Francis rivers. Further field work is necessary to the south, through the counties of Richmond, Sherbrooke, and Brome to the International Boundary, before a final report can be prepared.

## SUMMARY AND CONCLUSIONS.

Asbestos occurs in serpentine of two varieties which are thought to be of different ages. They may be conveniently called the Thetford and the Broughton types, and the rocks associated with them, the Thetford and the Broughton series, from townships in which they are well known.

Asbestos of the Thetford type occurs in veins, and is generally longer and stronger than that of Broughton. Chromite also occurs in the Thetford series. The asbestos of Broughton occurs principally as 'slip' fibre, or fibre arranged parallel to cleavage faces of the rock. It is more cheaply mined than that at Thetford, but being shorter and of less tensile strength it has a lower market value. The Broughton asbestos deposits are often associated with talc or soapstone, which is not found in any important amount at Thetford. There are no deposits of chromite in the serpentine of Broughton.

In both quantity and quality of the minerals produced, much the greater value is obtained from the serpentine of the Thetford type. It forms the greater part of the serpentine belt, and includes the mines of Thetford, Black Lake, and Danville, with much of the intervening areas. It also extends southward beyond the St. Francis river.

The Broughton serpentine contains the mines and prospects of East Broughton and the vicinity of Robertson. The property of the D'Israeli Mining Company, Limited, in Garthby, and some prospects in ranges I, II, and III of Tring, also belong to this class.

The production of asbestos has increased steadily from the beginning of mining in the district thirty years ago to the present. It now has an annual value of $2,500,000.

Chromite occurs in workable deposits in the Thetford serpentine, but not, as far as known, in that of Broughton. The value of the annual production for several years has been about $80,000.

Soapstone, or talc, is found in important quantity associated with the Broughton serpentine, but not with that of Thetford. Some shipments were made from these deposits over twenty years ago, but a stable industry has not yet resulted.

The serpentine of the Thetford class has been derived by alteration from peridotite. The origin of the Broughton serpentine has not yet been satisfactorily determined, but it has doubtless been derived from the same, or from a closely allied rock.

In both cases the original rock was a member of a series of intrusive rocks differentiated from a single magma. The series comprises peridotite, pyroxenite, gabbro, diabase, porphyrite, and hornblende granite, the latter sometimes passing into aplite. The granite has usually been injected a little later than the other members of the series, and, therefore, in many places forms dikes and sills or intrusive sheets. These probably had a favourable influence in the formation of asbestos deposits, especially in the vicinity of Thetford Mines.

The igneous complex takes the form of a batholith, or thick laccolith, in the area between Thetford and Danville, and elsewhere is in sheets or sills. The serpentine of the Thetford type occurs both in sills and batholithic masses, while the serpentine of Broughton is only in sheets or sills.

The different rock varieties are arranged in order of decreasing density: in sills, from the base upwards; in batholithic masses, from the centre outward. This order is peridotite, pyroxenite, gabbro, diabase, and porphyrite. The peridotite alters to serpentine, and the serpentine is purest and so most likely to carry asbestos, near the base of a sill, or the centre of a batholithic mass.

A result of this arrangement of the igneous rocks is, that, when the structure is known, the location of the purest serpentine may be determined. Most of the sheets dip towards the southeast, and in such areas the best prospecting ground is along the northwest side of the igneous belt. Where the sills dip to the northwest, the best prospecting ground is near the southeast border.

In the batholithic bodies serpentine is exposed only by erosion of the original rock masses. This has been most effective on the northeast side of the hills, that being the side against which the ice has moved in the glacial period.

Besides the purity of the original peridotite, which is necessary that pure serpentine may form, the degree of alteration of peridotite to serpentine is an important factor in the formation of asbestos. The degree of alteration is indicated by the relative hardness of the rock. If the original rock were a pure peridotite—that is, composed essentially of olivine—the more completely it is altered to serpentine the softer the resulting rock and the better the prospect for asbestos. But, if the original rock contained a considerable amount of pyroxene which has been altered to soapstone, the resulting rock may be softer than the purest serpentine, but will be unlikely to contain asbestos. Therefore, soft rock is a good indication of asbestos, if there is no soapstone present.

The presence of granite, also, seems to have a bearing upon the occurrence of asbestos veins. The granite rock has generally been injected later than the other rocks; it fills fissures formed in the solid peridotite and forms dikes and sills. Either the fissuring or the action of the granite in filling the fissures has probably aided in forming asbestos.

Since the parent rock of the serpentine was a deep-seated one, and since the alteration to serpentine may occur at great depths, there appears to be no reason why the asbestos deposits also may not continue to as great depths—probably to the limits of profitable mining.

The chromite occurs in segregated masses, that are thought to be primary, in the outer part of the peridotite or serpentine portions of the batholithic masses, near the pyroxenite zone.

Chalcopyrite and pyrite occur in bodies of possible importance, in the diabase of Garthby and other places in the district. They are thought to be primary segregations.

Antimony occurs in South Ham, as a contact deposit in schists, adjacent to serpentine and diabase. The deposit contains native antimony, kermesite, valentinite, and a little stibnite.

Platinum is known to occur in the drift, and this has come from the direction of the chromite deposits, which are the probable source of the metal.

## GENERAL CHARACTER OF THE DISTRICT.

### Physical Features.

The portion of the Province of Quebec which lies south of the St. Lawrence river consists of two distinct parts, the St. Lawrence plain, and the Appalachian highlands. The St. Lawrence plain, so-called, is really a broad, flat valley, which, since it has an average gradient of scarcely 10 feet in a mile, appears to be a level plain. It extends southeast of the St. Lawrence river for a distance of 50 miles near the International Boundary line, but grows narrower farther down the river, and terminates where the Notre Dame highlands reach the river about 100 miles below Quebec city. The St. Lawrence plain is part of the greater lowland which extends from the lower part of the St. Lawrence river to Georgian bay.

The highlands which form the rest of the Province south of the St. Lawrence are known as the Shickshock mountains, in the Gaspé peninsula; while in the southern part of the Province, or Eastern townships, they are sometimes called the Notre Dame hills. They are a northward extension of the Green and White mountains of New England, and form the most westerly member of the Appalachian mountain system in Canada.

The topography of the district is in an early stage of maturity. The altitude varies from 400 feet to 2,000 feet above sea-level. The relief is characterized by numerous northeast and southwest running ridges and valleys, and a smaller number of larger, transverse valleys.

The transverse valleys are those of the Chaudière, Beçancour, Nicolet, and St. Francis rivers. These rivers all follow northwesterly courses, and empty into the St. Lawrence. It is not yet known whether they are older than the present hills and have cut through the folds as they were formed; or have been superimposed upon them by the removal of later formations, of which remnants are found in the district.

The tributary streams often run in structural valleys, and are probably younger than the main rivers. They generally have narrow valleys with steep sides, and frequently enter the main rivers by distinct falls.

These furnish the principal water-power of the district, and have given rise to such manufacturing centres as the city of Sherbrooke, at the junction of the Magog with the St. Francis; or Windsor Mills, at the entrance of the Wattopekah to the same river.

While the country as a whole is fairly well cleared of timber, many parts of the more rugged surface of the serpentine belt are still densely wooded. In the valley through which the Quebec Central railway runs there is generally a heavy drift covering, which, with the thick second growth that covers the surface for several miles between Coleraine and Thetford Mines, makes detailed work in some places difficult. On the high land and hill tops forest fires have recently exposed much of the surface to view.

### Transportation and Communication.

The parts of the district in which the principal mining is done have good railway facilities. The asbestos mines of Thetford, Black Lake, and East Broughton are in no case more than a mile from the Quebec Central railway, and little farther from ship-

ping stations. Most of these mines have sidings, or short spurs connecting the mills with the railway. At Danville, the Asbestos and Asbestic Mining Company, Limited, has built a branch line, about 3 miles in length, connecting the mine with the Grand Trunk railway.

The areas remote from the railways are all accessible by public highways of the ordinary character. The chromite mines are less favourably situated in this respect, but none are more than 7 miles from a railway.

## GENERAL GEOLOGY.

The region of southeastern Quebec is underlain by strata of Palæozoic age, resting upon the Pre-Cambrian complex, which emerges from beneath the later rocks a short distance north of the St. Lawrence. The Palæozoic strata form an ascending series toward the south, except where folding and subsequent erosion have disturbed the order of exposure. Every formation from Cambrian to Devonian is represented.

The structure, however, is far from uniform. In the northwestern part of the St. Lawrence plain, the strata are conformable from Potsdam to Hudson River. They are little disturbed in position, and dip toward the southeast at a low angle, usually 5° or 6°. This regularity ends abruptly at the line of the St. Lawrence and Champlain fault, a great dislocation which extends from the foot of Lake Champlain northeasterly to Quebec city and thence to the Gulf of St. Lawrence, running in or near the present channel of the river. On the southeast side of this fault the strata are highly folded, and have otherwise suffered greatly from regional metamorphism. The conditions of deposition were also different. The marine fossil fauna indicate cold, perhaps subarctic, conditions, and an unconformity is found at or near the base of the Ordovician, which is not found on the west side of the fault.

Over considerable areas east of the fault, the folded rocks have been planed down by erosion, so that they now underlie the eastern part of the St. Lawrence plain without expressing their structure in the topography. The sediments of the region consist of shales, limestones, and sandstones, with schists, slate, and quartzites on the east side of the great fault.

The highlands, or Notre Dame hills, consist of three anticlinal ridges running in a northeasterly direction, with two broad, intervening basins, which each have a width of about 25 miles. The ridges are usually distinguished as the Sutton, Sherbrooke or Stoke, and Lake Megantic anticlines. The last forms a part of the boundary line between the Province of Quebec and the State of New Hampshire. The first mentioned is the most westerly of the Appalachian folds in this region, while the second forms the Capelton hills and Stoke mountain, in the vicinity of the city of Sherbrooke, and the hills of Weedon farther to the north.

The ridges contain a considerable development of ancient volcanic rocks, porphyry, and greenstones. These are overlain by sediments, some of which are probably of Pre-Cambrian age.

On the southeast side of the Sutton ridge and closely following its course is the series of basic intrusive rocks which form the serpentine belt. Entering the Province at the Vermont boundary line, they continue northeasterly, with little interruption, to the vicinity of the Chaudière river. They are part of a series of similar rocks which appear at frequent intervals in the eastern part of North America, from Georgia to Newfoundland. In Quebec, they consist of peridotite and serpentine, pyroxenite, gabbro, diabase, porphyrite, hornblende-granite, and aplite, and are regarded as differentiates from a single magma. They form hills 1,500 feet in elevation, covering 10 to 20 square miles in some parts, and in others appear as only narrow bands a few hundred feet wide. In width they rarely exceed 5 miles, and are usually less than 1 mile. In structure they are considered to form batholiths or thick laccoliths, and intrusive sheets or sills.


DIAGRAMMATIC SECTION ALONG POWER LINE OF ST. FRANCIS HYDRAULIC CO, BETWEEN THETFORD RIVER AND BISBY CREEK

Horizontal scale: 1 mile to 1 inch
Vertical scale: 2640 feet to 1 inch

In the area to be described the rocks of the serpentine belt cut no rocks later than Sillery (upper Cambrian), though they probably alter some Ordovician strata. To the south of this district, however, in the county of Brome, they cut Ordovician, and alter strata of Devonian age. It is not yet proven, however, that the rocks of the series were all intruded at or nearly at the same time. The rocks of the district thus far examined appear to be of at least two different ages, and other periods of intrusion may yet be found. Hence the age of the series as a whole can only be determined approximately.

TABLE OF FORMATIONS.

SEDIMENTARY.

| | |
|---|---|
| 1. Quaternary | Sands and gravels.<br>Stratified clay.<br>Boulder clay. |
| 2. Ordovician—Farnham? | Black slates.<br>Conglomerate. |
| 3. Cambrian—Sillery | Red and green slates and sandstones. |
| L'Islet | Quartzose, grey schists, and quartzite. |

IGNEOUS.

(Intrusive, and of different ages.)

| | |
|---|---|
| Post-Sillery; in part, at least, later than lower Devonian—Thetford Series | Peridotite, altering to serpentine.<br>Pyroxenite, gabbro, diabase, porphyrite,<br>Granite and aplite. |
| Post-L'Islet—Broughton Series | Serpentine.<br>Soapstone.<br>Greenstone schists. |

## Sedimentary.

QUATERNARY.

The covering of drift throughout much of the district is heavy. Sands, gravels, and stratified clays are found in all the depressions, and obscure the geological structure, especially in the valley through which the Quebec Central railway runs from D'Israeli to Thetford Mines. In the valleys of the principal streams well marked terraces have often been developed. An especially good example may be seen on the northeast side of the valley in which the road runs from Broughton station to Harvey hill.

No marine fossils have been found in these deposits. In composition they represent complementary parts of the underlying boulder clay, from which they have been principally derived.

The ice movement which has had the most marked effect on the surface of the country has come from the north-northeast, the general course being S 20° W. Another set of glacial striæ running northwest indicates a weaker glacial movement. The former of these ice movements has eroded the northeast side of the principal hills so far as to have an important effect on the exposure of the serpentine.

ORDOVICIAN.

A series of sediments which are near, but not in contact with, the intrusive rocks in this district, consists of graphitic, argillaceous, and sometimes calcareous slates. They are in many places soft and very fissile, and everywhere steel grey or black in colour.

They occupy a large part of the basin between the Sutton ridge and the next to the east, and so appear on the southeast side of the serpentine belt throughout the district, usually at a distance of less than a mile. They occupy the troughs of many of the minor synclines in the underlying sediments, and in such cases generally contain pebbles of earlier sediments. Such outliers approach nearer to the intrusives and may be cut by them, but no such contact has been found. The series is the lowest member of the Ordovician here found, and is tentatively referred to the Farnham series of the lower Trenton formation.

### CAMBRIAN.

The rocks which in most places border the serpentine belt are believed to be of Cambrian age. They occupy an area 5 to 10 miles wide, in which is included the outliers and erosive remnants of Ordovician mentioned above. The principal rocks of the series are red, green, and grey slates and schists, sandstone, and quartzite.

*Sillery.*—The red and green slate and the sandstone are a southerly extension of the Sillery formation of the vicinity of Quebec city and the lower St. Lawrence plain. This formation is regarded by Dr. Ells as belonging to the upper part of the Cambrian system.

*L'Islet.*—The grey schists and quartzites are lower members of the series. No fossils have been found in them, and no basal conglomerate, or other mark of unconformity, to indicate that the base of the group has been reached. While the rocks are principally sedimentary, some of the grey schists and slates may prove to be altered volcanics.

This formation has been previously called the L'Islet, from its large and well-defined development in L'Islet county beyond the northern boundary of the present district, where it is distinguished by its geographic position and stratigraphic relations, as well as by the lithologic characters of the rocks comprised in it.

### STRUCTURAL RELATIONS OF THE SEDIMENTARY ROCKS.

The boundaries between the Ordovician and the Cambrian are usually definitely marked by the conglomerate at the base of the former. This consists of pebbles of the underlying Cambrian sandstone in a matrix of the overlying Ordovician schist. It, therefore, marks an unconformity, indicating a time break between the two formations, and shows this part of the Ordovician to be the base of that system.

The lower limit of the Cambrian is not so well defined. No basal conglomerate, or other certain mark of an unconformity, has been found in this district, and it is a matter of some doubt whether the earlier intrusives of Broughton lie wholly in the Cambrian, or partly in still older rocks.

The strata here described are on the southeast side of the Sutton anticline, one of the major axes of the Notre Dame hills. Consequently the strata have a general dip toward the southeast, with minor folds giving dips in the opposite direction.

The axis of the first important syncline runs across the township of Broughton on lots 21 and 22 or 23. The trough of the syncline in Broughton is occupied by Ordovician strata, while Sillery measures appear at a distance of a mile on either side. The valley in which the Quebec Central railway runs from Thetford Mines to East Broughton is on the axis of the same syncline at Thetford Mines, but some 2 miles west of it at East Broughton. In the southwestern part of the district the structure is not as well expressed in the topography, but the general relations continue the same.

## Igneous.

THETFFORD SERIES.

The rocks of the Thetford series make up the greater part of the serpentine belt. In this district they extend southwesterly from Broughton mountain, in the township of Broughton, through Thetford, Coleraine, Ireland, Wolfestown, and Garthby to Big Ham mountain. After an interval of 4 miles they reappear in Little Ham mountain, and continue in a southwesterly direction to Danville, and thence to the St. Francis river. Diabase occupies the largest area of any rock of the series, peridotite and serpentine the next. Gabbro and pyroxenite also form considerable masses, while granite and aplite are of relatively small extent.

*Peridotite and Serpentine.*—Serpentine forms the country rock of all the mines, and, with less altered peridotite, makes up many of the larger hills in the mining district. The hills near Little Lake St. Francis, near Black Lake, in the southern part of Ireland, and between Belmina and Chrysotile, as well as smaller areas in other parts of the serpentine belt, are composed of serpentine and peridotite.

It is difficult, and often impossible, to distinguish these rocks in hand specimens. In the field, and in mining operations, they are collectively called serpentine.. The peridotite is composed of olivine, a small amount of pyroxene, and a little chromite and magnetite. The serpentine is merely an altered phase of the peridotite. The mineral serpentine is derived from olivine by a process of alteration, which consists principally of the addition to it of water, and the loss of its iron content. Pyroxene may also alter to serpentine; but it changes less readily than olivine, having originally more silica in its composition; and more frequently it alters to soapstone or talc. The olivine is sometimes completely altered to serpentine, while the pyroxene remains little changed. On freshly broken faces of serpentine, the pyroxene crystals, when any are present, show as glistening grains, usually ½ inch or less in diameter. On weathered surfaces they stand out in relief, giving a rough surface to the serpentine, like raised nail heads, or knots in a worn floor. This is well shown in the rock near the summits of the serpentine and peridotite hills, as, near the top of the hill above Black Lake village.

*Pyroxenite.*—When pure, pyroxenite consists of the mineral pyroxene. There is usually present, however, more or less olivine or feldspar, the former if the rock is approaching the composition of peridotite, the latter if it tends toward gabbro.

The pyroxenite near the Danville asbestos mines is singularly coarse-textured, and much of it is composed of large pyroxene crystals, some of which measure 2 inches or more upon single faces. In general, the pyroxenite is somewhat altered to soapstone.

*Gabbro.*—When there is feldspar as well as pyroxene present, the coarse-grained types have been classed as gabbro. It can be distinguished by its coarse texture, shown by angular grains of grey feldspar and green pyroxene. Gabbro forms a large part of the hills above Lac Coulombre, about Nicolet lake, and Little Ham mountains. It may be seen along the roadside near the southeast shore of Black lake, and in many other places near the foot of serpentine hills. The pyroxene is sometimes altered to hornblende; the rock is then more correctly called a gabbro-diorite.

*Diabase.*—The diabase has the same mineral composition as the gabbro, but is much finer grained, and generally has a quite different appearance. It is a fine, green rock sometimes showing small, grey grains of feldspar. In other cases no individual mineral can be distinguished by the unaided eye. The rock can often be readily recognized by nodules and stringers of yellowish-green epidote, a mineral that has been formed by the alteration of feldspar, and, in part, also of pyroxene. There is frequently a little quartz with the epidote.

Diabase may be well seen along the Quebec Central railway between Black Lake and Thetford Mines; also near the Roman Catholic church at Black Lake. It forms the hills about Clapham lake, and near the Little Nicolet lakes. It carries copper and iron pyrites, in places, as at Lac Coulombre. In places, the diabase, by becoming more acid in composition, and losing much of the pyroxene, passes into porphyrite near the outer edges of the mass.

*Granite.*—The granite in this area is composed of feldspar, quartz, and hornblende or mica (biotite), or both. It is light grey in colour, and occasionally shows a pinkish tint. Portions without hornblende or mica—principally dikes—are more properly classed as aplite.

The granite is in small amount in the district, but is important, as it probably indicates conditions that favoured the development of asbestos. It forms hills in the northeastern part of Coleraine, dikes in most of the mines, and, in places, isolated masses grading into the enclosing diabase or porphyrite. These isolated masses are, probably, primary segregations.

## Structural Relations.

(*a*) *External.*—The rocks of the Thetford series are very obviously intrusive in their relations to the enclosing sediments. Evidences of this are: alteration of the sediments in the outer contact zone; deflexion of their dip and strike; and developments of contact breccia.

The alteration of the sediments is sometimes shown by a hardening of a band near the contact, producing a hornstone rim. The grey slates are often given a rusty, reddish colour, due apparently to the oxidation of sulphides developed near the contact; while the originally red Sillery slates are usually bleached to pale pink. Fragments in the breccia, and larger portions of sediments near the contact, show partial absorption by the igneous magma. Some of these rocks still preserve the lines of foliation of schists on weathered surfaces, but on freshly broken faces they cannot be distinguished from the enclosing, or adjacent, igneous rock.

Dikes are very rare, and altogether there is a very noticeable absence of evidence of any violent eruption. The intrusion seems to have progressed slowly, and without any marked cataclysmic action. The contact is thus of the batholithic type.

The bodies of igneous rock appear to take two principal forms. From Broughton mountain to Little Nicolet lake, where the igneous belt crosses the stratification somewhat obliquely, the intrusions occupy elliptical or rounded areas, bordered by breccia, and giving evidence of downward enlargement. With the exception of one district, and two doubtful intervals, they form a continuous mass, and so are interpreted as being a batholith, or very thick laccolith.

In other parts of the district, the boundaries of the intrusions conform more closely to the stratification, are generally brecciated on one side only, and occupy long narrow areas. In cross section they can sometimes be seen to form sills or intrusive sheets, and are consequently considered to more generally take this form.

(*b*) *Internal.*—The peridotite, pyroxenite, gabbro, and diabase, form a continuous series, passing by gradual transitions from one variety to another in the order named. In the case of larger exposures, all of these rock types can sometimes be found in a single intrusive mass. In other cases, the differentiation is sharper, and peridotite passes into diabase with only a few feet of transitional rock between. In general, peridotite, or the serpentine derived from it, and diabase, form the larger portion of a rock mass. At the outer edges, the diabase, in places, passes into hornblende porphyrite, and this occasionally into hornblende granite, or aplite.

The granite and aplite have usually, however, been intruded a little later than the more basic rocks. The edges of these acid intrusions are generally as well crystallized as the central parts, showing that they were brought in while the basic rocks were still

heated. Occasionally, too, an injection of diabase has taken place somewhat later than the intrusion of the greater part of the mass. This may be seen at Louise mountain, in Garthby, and probably near Shipton Pinnacle, but such occurrences are not common.

The rocks of this igneous complex are generally distributed in one or other of two different modes of arrangement, according to the form of the igneous intrusion. They are arranged in order of decreasing basicity and density:—

(*a*) In sheets from the base upwards.

(*b*) In batholithic intrusions from the centre outwards. Serpentine, or diabase, may sometimes be much in excess of the other rocks, and thus give an asymmetric arrangement. But the more acid rocks, wherever present, are, as far as known, invariably nearest the tops of sheets or the margins of batholithic intrusions, and the basic rocks in correspondingly opposite positions.

In the case of sheets, the arrangement of the rocks accords with the relative densities of the principal minerals of which they are composed, and also with the order of their crystallization.

In the case of batholithic intrusions, the differentiation from basic to acid extremes, from the centre outwards, is in agreement with well known cases of magmatic segregation in intrusive rocks where differentiation has taken place prior to intrusion. The igneous complex of Magnet cove, Arkansas, is a parallel in alkaline rocks.[1]

An instance is given by Mr. Chas. Camsell (see Mr. Camsell's Summary Report in this volume) of a volcanic stock from the platinum locality in the Tulameen district of British Columbia, where a core of peridotite is bordered by a differentiated rim of pyroxenite. An adjacent intrusion of augite syenite took place a little later.

The batholithic intrusions near Thetford characteristically consist of a dome-shaped central mass of peridotite, bordered, or sometimes nearly surrounded, by an erosion valley. The outer side of the central mass is formed by a ridge of diabase, or porphyrite, which passes into breccia at its outer edge. These fractures can be seen in a section extending from the top of the hill above Black Lake station, which is part of the central dome, to the valley of the Thetford river, and thence to the diabase at the Roman Catholic church in the northern part of the village. (See diagram, page 185.)

### BROUGHTON SERIES.

The Broughton series consist of serpentine, soapstone, and greenstone schists. They are the rocks containing, and adjacent to, the asbestos and talc deposits of Robertson, East Broughton, and Broughton, and of several isolated locations in the vicinity.

The rock differs from that of Thetford and Black Lake, in being much softer and more shattered. It is almost completely serpentinized, the only exception being certain hard blocks which carry no asbestos. The asbestos that is recovered here rarely occurs in veins, but generally as slip or parallel fibre, being, in fact, only the softer and partially fibrous, outer portions of the individual pieces into which the rock is shattered. A microscopic examination of these rocks is still necessary in order to determine the actual mineral composition of these hard blocks, and to find out, if possible, whether the asbestos-bearing portion was originally similar to that in the Thetford series. The presence of considerable bodies of talc, and steatite or soapstone, indicates that there was a good deal of pyroxene in the original rock. There is very little chromite in the serpentine of this class.

The altered greenstones are chloritic and epidotic schists, which probably were originally diabase, together with hornblende schists which grade into them. The latter

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[1] Washington, H. S., 'Igneous Complex of Magnet Cove.' Bulletin, U.S. Geol. Surv., Vol. XI, pp. 389-416, 1900.

may be the altered, more acid parts of the primary rock, perhaps corresponding to the porphyrite of the Thetford series. The precise character of these rocks can only be determined by detailed lithological examination, which has not yet been made.

The greater alteration of these rocks indicates that they are earlier in age than the Thetford series. The rocks enclosing them are the grey schists and quartzites—in no case the red slates, of the Sillery formation. It can, therefore, only be said of their relations that, they are intrusive in, and hence later than the L'Islet formation which conformably underlies the Sillery.

## ECONOMIC GEOLOGY.

The minerals of economic value that have been found in the serpentine belt are asbestos, chrome iron ore, talc, antimony, copper, and platinum. Of these, asbestos and chrome iron ore are at present being mined; the former constituting in value one-half of the total mineral production of the Province of Quebec, and producing upwards of 80 per cent of the world's supply of asbestos. Antimony and talc have been mined; there has been a small development of the copper ore; and platinum has been found in the gravels.

### Asbestos.

*History.*—The discovery of asbestos in commercial quantities in this district dates from 1877, although it was known for many years previously as a mineral occurrence of prospective value. Mining operations began at Thetford, Black Lake, and Danville very shortly afterwards, and have continued ever since. Since the introduction of a successful method of mechanical concentration, about 1893-4, the production has increased regularly, until it now has an annual value of $2,500,000. Notwithstanding this steady and increasing production, no well-established mine has yet been worked out. Aside from the abandoned pits incidental to early prospecting, the only closed works are those of ill-judged enterprises that probably ought never to have been begun.

The production for the past four years has been as follows:—

| | Tons. | Value. |
|---|---|---|
| 1905 | 50,669 | $1,486,359 |
| 1906 | 60,761 | 2,036,428 |
| 1907 | 62,130 | 2,484,767 |
| 1908 | 66,548 | 2,555,361 |

In addition to this, there has been produced 'asbestic' to the value of $17,974 during the past year.

The asbestos is of the chrysotile variety—hydrous silicate of magnesium—and has the same chemical composition as the serpentine rock which contains it, but is distinguished from it by its fibrous form.

*Character of the Veins.*—In the Thetford-Danville section, the asbestos occurs almost wholly in veins which are usually 2½ inches or less in width, the greater number being less than ½ inch. The fibres lie at right angles to the walls of veins, hence the length of the fibre is limited by the width of the vein; but it rarely equals it; for there is usually a parting in the vein which is marked by a film of iron ore, generally magnetite. The veins are invariably bordered by a band of pure serpentine on each side of the vein, whether the country rock be a serpentine or partially one, or even a slightly altered peridotite. These serpentine bands bordering the veins are usually as well defined as the vein itself, and in width are proportionate to it, each being nearly three times the width of the asbestos vein.

From a consideration of these facts, and of the number, size, and directions of the veins, it is believed that they were formed not by the filling of once open fissures, but by the replacement or crystallization—more or less perfect—of the pure amorphous

serpentine of the side walls. This process is thought to have begun at a fracture now indicated by the parting or film of iron ore within the vein, and to have extended into the wall rock on one or both sides to a distance proportionate to the width of the serpentine bands. They thus belong to the class of veins sometimes called oxogenous or *outward* growing, as distinguished from those that are formed by filling a fissure from the edges *inward*. Measurements of many veins have been made, which show the proportion of asbestos to the two bands of serpentine and the included asbestos to be 1:6·6, or that approximately 15 per cent of the serpentine has taken the crystalline form of asbestos.

*Origin of the Fractures.*—In the Thetford or later serpentine many of the larger veins can be seen to follow joint planes in the original rocks. Another class seems to have grown from fractures caused by regional folding, as is indicated by their approximate parallelism. Fractures produced in early stages of disintegration of the rock by casting off shells from the jointed blocks give a series of crescent-shaped veins, surrounding a core of peridotite. Where all of these classes of veins are found together there results a very intricate network, but by careful observation many of them can be referred to one or other of these classes.

In the supposedly older serpentine of East Broughton there are comparatively few veins. The exact mode of occurrence of the asbestos in this rock has not yet been studied in detail, but the asbestos seems to occur as 'slip' or 'parallel' fibre, which is on or in the rock, parallel to cleavage faces.

Other causes of the shattering of the rock, such as hydration, rapid cooling, and, possibly, original gneissic structure near the edges of an intrusion, require a full investigation covering the entire process of serpentinization.

*Mining.*—All the mines are worked by open-cut methods. The ground at the bottom of the pit is usually cut into a series of benches, generally about 8 to 15 feet high, which afford a number of faces from which the rock can be quarried at the same time. At the Bell mine, Thetford, extensive underground work has been carried on in winter with apparent success. Generally, the mines are operated only by day. At the King mine, Thetford, work is carried on in the pit at night by the aid of search lights. At the Danville mine, some underground work was carried on by night during the last summer. Several of the pits have reached a depth of about 200 feet, with two or three times greater horizontal extension.

*Handling and Dressing.*—In some of the mines the asbestos-bearing portion is separated from the barren rock in the pit, and in part the crude from the mill stuff, and each is loaded into separate boxes and hoisted to the surface. A certain amount of hand cobbing is also done in some pits. In most, however, all hand separation is done at the surface. There, the separate products are emptied into tramcars, which are usually drawn by small locomotive engines; the dead rock is then taken to the waste dump, and the rock which will afford crude asbestos, to the cobbing sheds, where it is separated by hand work and put in bags. The remainder, usually 35 per cent to 60 per cent of all the rock handled, goes to the ore bins, or, in some cases, directly to the mill for mechanical concentration.

This concentration is an ingenious process, which has been developed by some of the pioneer mine managers of the district. The essential features are successive crushings and screenings of the rock, and the removal of the asbestos thus liberated by means of suction fans. The crushing is effected by jaw and rotary crushers of the standard type, and a finer crushing is frequently effected by means of rolls. After the first crushing much or all of the material is dried in rotary driers, with direct heat.

A final pulverizing of the rock is accomplished by a specially designed machine known as the cyclone. This consists of two 'beaters,' or heavy screw propeller-like fans of chilled iron, set end to end, which revolve at a speed of 2,000 revolutions per

minute, or more, in opposite directions in a closed chamber. The small rock fragments are thus driven together with such force as to reduce them to powder, and the smallest particles of asbestos are released and collected as before.

The fibre drawn off at the various stages of the milling process is collected in settling chambers, and conveyed to a rotary classifier, by which the product is separated into various grades according to the length of the fibre.

Suction fans for the removal of dust from the cyclone, the classifier, and sometimes from the mill are important accessories to the equipment. Magnets are usually employed over the shaking screens to eliminate particles of iron ore.

The various mills differ from one another in details, some of which are regarded as more or less secret features, but the general practice is essentially uniform. The milled fibre is classified into three or more grades, and the crude asbestos usually in two. The question of adopting a standard classification is being discussed.

*Prices.*—The following production by classes, as compiled by Mr. J. McLeish, Chief of the Division of Mineral Resources and Statistics, of the Mines Branch, Department of Mines,[1] shows the proportions of different grades, classified according to value:—

| —— | Short tons. | Value. | Range of price per ton. | Average price per ton. |
|---|---|---|---|---|
| | | $ | $ cts. $ cts. | $ cts. |
| Crude No. 1 | 857½ | 257,752 | 267 00 to 350 00 | 300 59 |
| " No. 2 | 2,488 | 411,480 | 75 00 to 225 00 | 165 38 |
| Mill Stock No. 1 | 5,282½ | 425,448 | 60 00 to 100 00 | 80 54 |
| " No. 2 | 45,545¼ | 1,345,750 | 20 00 to 50 00 | 29 33 |
| " No. 3 | 12,374¼ | 114,931 | 5 00 to 13 00 | 9 29 |
| Total Asbestos | 66,548 | 2,555,361 | 5 00 to 350 00 | 38 40 |
| Total Asbestic | 24,225 | 17,974 | 35 to 1 16 | 74 |
| Grand Total | 90,773 | 2,573,335 | | |

*Uses.*—A small proportion of the asbestos produced, all of the highest grades, is used in making asbestos cloth and various fire-proof textiles; while much the greater part is used for covering, and insulation purposes. Boards, shingles, and roofing felts for fire-proof construction, materials for electric insulation, and protection from acids, boiler and pipe coverings are among the products in common use.

The manufacture of asbestos goods has hitherto been carried on practically only in Europe and the United States. During the past year, however, a plant for the manufacture of asbestos shingles, mill-boards, and covering material has been established at Lachine, Quebec, by The Asbestos Manufacturing Company, a Company allied to the long-established manufacturing firm of Keasbey and Mattison, of South Ambler, Pennsylvania.

*Mines.*—A list of the mines, with more or less detailed description of their equipment and capacity, as well as their financial organization, has been published in the Report of the Mining and Metallurgical Industries of Canada, issued by the Mines Branch of the Department of Mines, in December, 1908, and hence need not be repeated here. The following are the mines that have produced asbestos during the

[1] 'The production of Asbestos in Canada,' 1907-8, by John McLeish. Mines Branch Publication No. 44.

past year, and all in operation at the close of the summer. They are named in order of location, and the names of the owners and of the shipping stations are also given:—

King: Owners, The Amalgamated Asbestos Corporation, Thetford Mines, Quebec Central railway.

Bell: Owners, Keasbey & Mattison, Thetford Mines, Quebec Central railway.

Johnson: Owners, The Johnson Asbestos Company, Thetford Mines, Quebec Central railway.

Beaver: Owners, The Amalgamated Asbestos Corporation, Thetford Mines, Quebec Central railway.

Union: Owners, The Black Lake Consolidated Mining Company, Black Lake, Quebec Central railway—re-opened late in the season.

Johnson: Owners, The Johnson Asbestos Company, Black Lake, Quebec Central railway.

British American: Owners, The Amalgamated Asbestos Corporation, Black Lake, Quebec Central railway.

Danville: Owners, Danville Asbestos and Asbestic Company, Danville, Grand Trunk railway.

Standard: Owners, Amalgamated Asbestos Corporation, Black Lake, Quebec Central railway.

Dominion: Owners, Amalgamated Asbestos Corporation, Black Lake, Quebec Central railway.

Robertson: Owners, Robertson Asbestos Mining Company, Thetford Mines, Grand Trunk railway.

Broughton: Owners, Broughton Asbestos Fibre Company, East Broughton, Quebec Central railway.

Eastern Townships: Owners, Eastern Townships Asbestos Company, East Broughton, Quebec Central railway.

Quebec: Owners, Ling Asbestos Company, East Broughton, Quebec Central railway.

Frontenac: Owners, Frontenac Asbestos Mining Company, East Broughton, Quebec Central railway—equipped late in the season.

*Properties under Development.*—The Thetford Asbestos Company, about to be reorganized as the Jacobs Asbestos Company, has done some development on lot 28, range VI, of Thetford, with promising results. The construction of a mill has been begun, and the property is likely soon to be an important producer.

On the property of the Imperial Asbestos Company, a short distance south of Black Lake station, some development has been done by the Black Lake Consolidated Company, and it is announced that a mill is to be built. On the Southwark property, lots 27 and 28, range B, of Coleraine, the same Company made some very successful developments, and propose operating the property in conjunction with the Union mine, which it adjoins. A new mill is to be built to serve both properties.

The adjacent property of Dr. James Reed, in range A, Coleraine, which has had considerable development, and is partially equipped with a mining plant, has remained unused for some time.

The King property, lot 26, range III, of Ireland, and the Belmina, lots 23, 24 and 25, range II, of Wolfestown, are also partially developed properties which have not been recently worked. Both seem to give promise of favourable development.

The D'Israeli Asbestos Company has built a mill on lot 16, range III, of Garthby, and upwards of 4 miles of track to connect it with the Quebec Central railway, and is now preparing to develop the property.

At lot 24, range IV, of Wolfestown, an extensive mining and concentrating plant was installed a few years ago by the Asbestos Mining and Manufacturing Company, of Providence, Rhode Island. But the development of the property proving unsuccessful, the plant has been partially dismantled after lying idle for two years, and the property has lately changed hands.

At the Boston Asbestos Company's property, East Broughton, a mill has been built, and some development work done on a property adjoining that for which the mill was built. The mill and mine were not in operation at the time of our visit.

In lot 9, range V, of Thetford, the Beaudoin and Audet Company has done some development, as has also the Berlin Asbestos Company on lot 2 of the same range.

In lot 14, range VII, of Broughton, the old Fraser mine, once celebrated for the remarkable quality of the asbestos produced from a single vein, remains unworked. There seems likely to be a workable quantity of lower grade fibre in this property.

In all the mines of East Broughton the principal work has been done near the hanging-wall or top of the serpentine sheet, and the opinion prevails that the lower portion, that is the northwest side of the serpentine, is unproductive. The rocks of this locality have not yet been examined microscopically and chemically, hence, comparison is difficult. But in the rocks of the Danville sheet the best serpentine is at the north side, or near the foot-wall.

It would, therefore, seem advisable to test the serpentine at East Broughton near the northern edge, where asbestos, if it occurs at all, is more likely to be in well-defined veins and of greater tensile strength.

*Prospects.*—Asbestos has been found in various places in the district, by prospecting at different times, where little or no work has been done. In the East Broughton district, lot 13, in ranges III and IV, serpentine-bearing asbestos is shown by pits or natural exposures for a distance of several hundred feet in each range. The access to the railway is somewhat less easy, but the quality of the rock seems to compare favourably with that of the working mines at East Broughton.

Southwest of the mines of East Broughton, serpentine is found on lot 13, in ranges VIII and IX, of Broughton. In range IX it passes into lot 12, about 600 feet from the north end of the lot, and next appears near the northeast end of lot 11, in range X. From this point the serpentine appears at frequent intervals in two sheets running in a northwesterly direction to lot 2, in range XI. This change of direction in the outcrops of serpentine is caused by an arching of the strata across the strike, which gives the rocks a low northeasterly pitch, instead of a southeasterly dip. Consequently some parts of these serpentine sheets have a nearly horizontal roof of slate, and will be unavailable, since both the serpentine and the slate are too much fractured to admit of underground work, even if the prospects otherwise warranted it.

On the southwest side of this arch the serpentine is again found on lot 12, range XI, of Broughton; and in lots 1, 3, 10, 11, and 13, in range V of Thetford. Lots 2 and 9 in this range contain the properties of the Berlin Asbestos Company, and the Beaudoin and Audet Company, respectively, already mentioned; while the Robertson mine is situated on lots 16 and 17, in range XIII. The occurrence of serpentine on lot 13, range V—the property of Dr. James Reed—has led to some development work which seems to indicate that the rock is fairly productive in asbestos of the East Broughton or older type.

In lot 24, of ranges I, II, and III, of Tring, a small amount of serpentine is exposed, which contains a little asbestos. A very small amount of work was done here twenty years ago. The Tring branch of the Quebec Central railway cuts the serpentine near the line between ranges II and III.

Near Thetford Mines, prospecting was pushed on the Clarke property, lot 24, range A, Coleraine, and some work was also done on lot 27, range VI, of Thetford, by Jos. Demers and others.

The property in block B, Coleraine, formerly owned by the Coleraine Mining Company, but now belonging to the Black Lake Consolidated Company, is not being worked. A little prospecting was done near Coleraine during the past summer on lots 35 and 40, range II, of Garthby, and on lot 2, range VI, of Coleraine. No very definite results had been reached at the time of our visit.

South of the road from Coleraine to Wolfestown, several properties along the Belmina hill, chiefly in lots 23, 25, and 26, of ranges III and IV, show a little asbestos, but they have, generally, been little prospected. In lot 13, range VI, of North Ham, there is a small knoll of serpentine, on the south side of which there is a perpendicular face about 25 feet high. On part of this cliff face, about 15 x 20 feet, several veins of asbestos from 1 to 2 inches in width, and of excellent quality, are exposed. A small cutting on the top of the cliff did not show the veins to extend beyond a foot from the face of the cliff, while four small pits on other parts of the knoll did not disclose any veins of asbestos. The serpentine, which is several miles from any other known exposure, has a maximum breadth of 350 feet, and can be traced upwards of 1,000 feet on this property, and is recently reported to have been found to extend to lot 11 in range V. In view of the excellent quality of the small amount of asbestos exposed, it is to be hoped that the property will be thoroughly tested.

In range XI, of Tingwick, lots 20-25, there is a considerable area of serpentine, which has not been well prospected owing to the thickly wooded character of the area. Near the boundary of lots 21 and 22, the property known as the Ladysmith mine has had some development and equipment, including an extemporized mill. Work was closed at the time of our visit in July. There are other prospects between this property and the shore of Nicolet lake; but practically no work has been done upon them.

On lot 10, range III, of Shipton, adjoining the mine of the Danville Asbestos and Asbestic Company, the presence of asbestos-bearing serpentine beneath several feet of soil has been proven by a shaft. The question of economically utilizing the property at present has been further complicated, if not rendered impossible, by the sale of a portion of it in small building lots to several different owners.

A band of serpentine extends from the Shipton Pinnacle to the St. Francis river, a distance of 8½ miles. It occupies a part, or all, of lot 10, range VII, and lots 8 and 9, in range VIII, of Shipton; and in Cleveland, lots 8 and 9 in range IX, 7, 8, and 9 in range X, 7 and 8 in ranges XI, XII, and XIII, 6 and 7 in range XIV, and 6 in range XV. The northwestern edge of this band is a soft, but generally massive serpentine, and asbestos up to 1 inch in length has been found in several places. This is the largest unprospected or little prospected area in the district. It is not to be confused with a series of isolated outcrops of serpentine which are found nearly a mile to the northwest of the main band, running through lots 9, 10, and 11 in Cleveland, and 12 in Shipton. These are usually composed of a harder and less promising variety of serpentine; but on lot 12, range V, of Shipton, where it is associated with granite, one of these outcrops of serpentine contains a limited amount of asbestos.

## Chromite.

Chromite, or chrome iron ore, is an oxide of chromium and iron. It is useful not as an ore of iron but for its content of chromium.

Various attempts to mine this ore in Quebec were made between 1860 and 1890, but it was not until 1894 that any considerable production was made. Since that date over 400,000 tons of chromite have been mined, which had a value at the railway of about $600,000. The production for the last four years has been as follows:—

| | Tons. | Value. |
|---|---|---|
| 1905 | 8,528 | $104,565 |
| 1906 | 8,750 | 92,100 |
| 1907 | 7,196 | 72,901 |
| 1908 | 7,225 | 82,008 |

*Mode of Occurrence.*—The ore is in irregular masses, sometimes having the shape of flattened lenses. The largest single body of ore known in the district is 80 feet long x 5 feet to 50 feet wide, and has been proven for a depth of 300 feet or more.

Chromite in disseminated grains is found throughout practically all of the serpentine and peridotite; but in quantities large enough to form ore bodies it has been found principally in the peridotite near its outer edge, that is, close to the pyroxenite margin. The Dominion pit of the Black Lake Consolidated Company is at the southeast edge of the serpentine, and some 200 feet from diabase. The intervening ground is drift-covered, as is commonly the case in that portion of the batholithic masses. The American mine is on the northwest edge of the same mass. The Caribou pit, and the Black Lake pit No. 1, are near the southwest edge of the peridotite, where the latter carries considerable pyroxene. The Canadian Chrome Company's mine is on the southeast side of the same mass as the Caribou and Black Lake. The Breeches Lake or Leonard property, in Garthby, is on the south side of a serpentine hill with the acid rocks running around the foot, while the St. Onge, Adam, and Brosseau properties are similarly situated with regard to the serpentine hill northeast of D'Israeli.

The masses of ore are separated from one another by bands of rock of varying thickness, which makes regular production difficult. The ore occurs in a zone, that can probably be defined by a study of its place in the rock series; but this involves more detailed examination and mapping than has yet been found practicable.

*Mining.*—Mining is carried on in open-cuts, except at the Black Lake pit No. 1, where a shaft has been sunk. As the ore bodies are often small and discontinuous, the least expensive methods of working have usually been adopted. Power drills and derrick hoists are the principal equipment used. The diamond drill has been used successfully for prospecting.

*Concentration.*—The ore is bought and sold on a basis of 50 per cent chromic oxide. If higher than this, a premium is paid, if lower the ore is penalized. Consequently ore carrying approximately 40 per cent is shipped as crude; all from that quality to about 10 per cent is concentrated to 50 per cent or a little higher. The highest percentages reached in either crude or concentrated ore is rarely above 55 per cent, $Cr_2 O_3$.

The method of concentration that has been followed recently consists, successively, of crushing, stamping, and concentrating by means of Wilfley tables. The middlings from the first Wilfley's are usually treated on a second table, and a product rarely exceeding 51 per cent or 52 per cent is obtained. No data is at present at hand as to the percentage of recovery. There is, however, an apparent loss in 'float,' or very finely crushed ore, which is carried from the tables with the lighter rock particles.

*Uses.*—A limited quantity of these ores was used for a time by the Electric Reduction Company of Buckingham, Quebec, in the manufacture of ferro-chrome. Except for this, and occasional small shipments to Europe, the Canadian production is shipped to the United States. It is there used in the manufacture of bichromates for use in dying textiles, tanning leather, for pigments used in printing and painting, and in making chrome steel, and the lower grades for lining furnaces.

## Antimony.

The only occurrence of this mineral that is yet known in the district is in range I of South Ham, lot 28 of the old, or 56 of the later numbering, on the property of Dr. James Reed, of Reedsdale, Province of Quebec.

The ores are native antimony, with less amounts of stibnite, kermesite, and valentinite. The deposit is said to have been found in 1863, and to have been soon after developed and equipped with a mining and concentrating plant. After a time the works closed, and the property passed into the hands of the present owner.

The development, as far as could be made out in the present state of disrepair, consisted of four shafts. An adit, which could not be entered at the time of our visit, starts at a lower level some 300 feet from the main shaft, and is said to reach it at a depth of 100 feet. Considerable drifting is reported to have been done along the length of the ore body.

*Character of deposit.*—This is a contact deposit, in which the ores occur in schists along their contact with an intrusion of diabase and serpentine. The schists strike N 50° E magnetic, and have a vertical dip. A serpentine ridge runs east and west. The serpentine just north of the main shaft is exposed for about 150 feet in length, east and west, and has a breadth of 75 feet. It is bordered by diabase on the west and northwest sides, but on the southwest comes directly in contact with the slates of which it contains fragments. The principal workings are at the south contact of the serpentine with the schists, with one small shaft on the northwest side of a similar hill, about 1,000 feet east of the mouth of the adit. As these two intrusions of serpentine are doubtless connected at no great distance beneath the slates, it is not improbable that antimony may be found in the intervening distance. On the other hand, this structure lessens the probability of the deposit continuing to a great depth.

No distinct veins of any considerable width could be found in the present state of the workings, but the principal amount of ore seems to be in flakes, along the cleavage planes of the schists. The proportion of ore becomes greater as the contact is approached.

Two specimens of antimony ore from this property which have been assayed for gold by Mr. H. A. Leverin, of the Mines Branch, yield only a trace.

## Talc.

Steatite or soapstone—as well as the purer forms of talc—occurs in numerous places in the townships of East Broughton, Broughton, and Ireland. It generally bears the same relation to the older serpentine that pyroxenite has to peridotite. It is an altered form of pyroxenite, and in some places shows distinct pseudomorphs of steatite after pyroxene.

Soapstone has been quarried to a small extent at the old Fraser mine, East Broughton, lot 14, range VII, and on lot 5, range V, of Thetford. A considerable quantity is easily available on lot 2, range XI, of Broughton, and Ham, lots 42, 43, and 50, range I.

A better quality of talc is found on the farm of W. I. Porter, lot 2, Craigs Road range of Ireland, where it probably occurs in workable quantity.

## Platinum.

A small amount of platinum was reported to have been found in the gravels near the Chaudière river, in the county of Beauce, by T. Sterry Hunt, in 1852. The natural habitat of platinum is in chrome-bearing peridotites. These gravels are 30 miles southeast of the serpentine belt, and it is altogether probable that they have been in part derived from it. A nugget of platinum has also been found at Plattsburg, N.Y., some 50 miles south of the serpentine belt in Brome. In the Tulameen district of British Columbia, Mr. Camsell finds the platinum to occur with the chromite. Two specimens of chromite from Black lake, which have been assayed by Mr. H. A. Leverin, Mines Branch, Department of Mines, have yielded no platinum.

## Copper.

Chalcopyrite is found in small quantities, apparently as primary segregations, near the outer edges of the diabase in many places in this district. Most of them, however, are mere mineral occurrences, and not of commercial importance.

On lot 22, range I, of Garthby, is the property known as the Coulombre mine, on which a shaft was sunk over forty years ago. The ore is a compact pyrite carrying a small copper content. It is extremely free from silica, and should be useful in conjunction with some of the siliceous copper ores of the Capelton district.

While there is little facility for finding the limits of the ore body, the extent over which isolated exposures are found indicates the possibility of an important ore body: perhaps like one of those found under similar conditions to the southwest of this district, at the Huntingdon and Lake Memphremagog mines.

Smaller amounts of a better grade copper ore occur near the north shore of Clapham lake, on lot 15, range VIII, of Thetford. This is also in diabase near the contact with slate.

In lots 8 and 9, range I, of Wotton, diabase carries a little disseminated pyrite over an area of some 20 acres. It is possible that by stripping the soil from the rocks the ore might be found to be concentrated in places, into workable deposits.

# OIL-SHALES OF EASTERN CANADA.

*(R. W. Ells.)*

## INTRODUCTION.

The work of the past season was largely in connexion with the oil-shales of eastern Canada, and was a continuation of that of the previous year. The extent, distribution, and economic value of the oil-shale deposits of New Brunswick, Nova Scotia, and Gaspé were ascertained as carefully as was possible in the time available. Collections of samples were made from various points in the several provinces where such shales are exposed, and these were examined by Mr. H. A. Leverin in the laboratory of the Mines Branch, Department of Mines, at Ottawa. In this way their contents in crude oil and sulphate of ammonia were ascertained.

## OIL-SHALES OF NEW BRUNSWICK.

In the following account of the season's work, the various areas of oil-shales in New Brunswick are treated in the order in which they were visited. The first to be described is that of the Albert shale series of Albert and Westmorland counties, as found in an area situated about 30 miles from the Intercolonial railway, and extending from Memramcook and Upper Dorchester on the east nearly to the western line of Albert county, with a breadth varying from 1 to 6 miles. Farther west the formation is found in Kings county, between Sussex and Bloomfield, south of the Intercolonial railway. These several areas have been described in former reports on the district, and are all easily accessible.

At Albert Mines, which, in so far as mining is concerned, is the most important oil-shale area of New Brunswick, and is distant about 20 miles by road south of Moncton, large samples of the several varieties of oil-shale were collected, sent to Ottawa, and carefully analysed. The results of these analyses will be found under the heading, Albert Mines.

Thence, the examination extended eastward past Hillsborough and across Petitcodiac river to the Memramcook, where the village of Taylorville, easily accessible from Dorchester, is located. Here, also, samples of the black, oil-shale bands were collected, and, on being tested, were found to be very high both in crude oil and ammonia; the results of the analyses will be found under the head of Taylorville shales. Returning by way of Memramcook and Dover, other collections were made near Dover, mostly in somewhat thin shales which, however, were of good quality. The results of the analyses of these shales are given under the head of Dover shales.

Returning thence to Albert Mines, the areas westward were further examined, and specimens obtained at most of them, or wherever—according to our field test—the quality of exposed shale seemed worthy of further examination. These areas, in their order westward from Albert Mines, are: Baltimore, Turtle creek, Prosser brook, Pleasant Vale, Mapleton, and Elgin and Goshen near the western limit of the county. The results of the several analyses from the various localities are given under the proper heading of the district.

Throughout the several areas, it will be observed from the analyses that, the values in crude oil and ammonia gas, of the oil-shales from the different places, vary very considerably. The shales themselves vary much in character, ranging from a thin-bedded, brownish or blackish-grey, sometimes quite flexible and elastic,

often rich in fish remains, and usually known locally as 'paper shales,' to massive bands of black or brownish-black, tough shales, which occur as interstratified beds in the formation as a whole. While the greater part of these shales are bituminous, the black, massive beds, which range in thickness from 3 to 7 feet, are, on the whole, by analysis, much richer in ammonia gas and crude oil than the great mass of the thinner shales; though even in these, as far as tested, large portions are sufficiently rich in hydrocarbons to render them available for distillation.

In the western part of Albert county, toward Mapleton and Elgin, the shales, while preserving the general character of the Albert shales, have, on analysis, been found to be much poorer in hydrocarbons than those of the Albert Mines and Baltimore district. This is also true of the deposits found in Kings county.

It is interesting to learn from the work of the past season that, the ascertained values of many of the Canadian deposits greatly exceed what was at first supposed. It may be readily asserted that, in these deposits, considering the richness of much of the shales, their large extent—especially in the Province of New Brunswick—and their general accessibility and the facility with which they can be worked, Canada possesses a source of mineral wealth, the great value of which, if properly developed, can be scarcely overestimated.

In view of the great interest now being taken in the bituminous and oil-shales of the Albert series, both as regards the proposed extraction of oil by distillation, and systematic boring, the following synopsis dealing with the geological sequence of the strata of which the oil-bearing rocks are a part, may possess some points of interest.

The bituminous or oil-shales found in New Brunswick belong to what is known as the Perry formation, which unconformably underlies the marine limestone, associated gypsum, red marls, and the red, grey, or green conglomerates of the lower Carboniferous. In New Brunswick, the basal part of the Perry is represented by some hundreds of feet of reddish-brown, sometimes greyish-green, conglomerates, with which shaly beds, both red and green, are interstratified.

The lowest conglomerates of the Perry formation, as seen in the section on Kennebecasis island, are made up largely of fragments of Pre-Cambrian rocks, including crystalline limestone, granite, felsite, diabase, etc. At the base the pebbles are often from 12 to 18 eighteen inches in diameter. The conglomerates contain interstratified, irregular beds of red, sandy, and micaceous shale. Ascending in the series, the conglomerates gradually become finer, and are regularly interstratified with beds of grit and shale, the red and brown colour gradually gives place to grey, and the series becomes almost entirely a shaly one, the beds being grey and dark, sometimes black, shales interstratified with beds of a rather coarse, greyish grit. The darker shales have an abundance of plant and fish remains, corresponding, in this respect, with the shales of Albert and Westmorland counties. There is only a slight trace of bituminous matter in the shales of Kennebecasis island; but following them eastward they change in character and become bituminous, sometimes brown, pyroschists, containing sufficient hydrocarbons to render their ignition easy. Above these shales, and even forming a part of the shale series, are beds of greyish, sandy grit, containing oil, which can be obtained by boring in well selected spots, but, so far as yet known, in small quantities only. The bituminous shales, popularly designated as the Albert shales, do not yield oil in the free state as far as known.

In former years, in the selection of sites for boring, sufficient attention was not paid to the generally much disturbed character of the formation as a whole, the strata of which are often highly inclined, considerably faulted, and in places completely overturned, thus presenting features opposed to the formation of oil-reservoirs of any size. In recent operations—now being carried on in the Petitcodiac district by Mr. J. A. L. Henderson—this feature of the complicated structure is being taken into consideration, and the borings now being made have been located with due reference to the stratigraphical relations of the oil-sands proper. As a consequence, in the area

west of the Petitcodiac river and south of Stony creek, recent boring—though much delayed owing to loss of tools in the operations—has resulted in finding crude oil in fairly satisfactory quantity in at least one hole, and natural gas in at least two holes. Work in this area is now contemplated on a large and commercial scale, the present indications being quite favourable.

An interesting feature in connexion with the rocks of the Perry formation is seen in the elevation known as Indian and Lutz mountains, about 8 miles north of Moncton. In 1881, a short time was spent by one of my assistants—Mr. W. Broad—in making a survey of a part of the district, but the work was not finished. He recognized, however, the presence of a considerable mass or ridge of felsite which was supposed to be an extension of the Kingston formation and to be of Pre-Cambrian age. This was surrounded by a series of dark red conglomerates, at that time supposed to be of lower Carboniferous age, which in turn were overlaid by shales of various colours, among which were areas of brownish Albert shales, low in bituminous matter, but with the characters of Albert shales well developed. These conglomerates, on a recent examination, were recognized as a part of the Perry conglomerate, and they evidently underlie the mass of shales which make up the great bulk of these two mountains. As a rule, the associated shales are steeply inclined, and show the presence of faults and, possibly, overturns as the igneous mass is approached. They are succeeded elsewhere by a series of sandstones which may represent the oil-sands of the Petitcodiac River section; but in order to establish definitely the actual structure of this area a more detailed survey of the district will be necessary.

## Albert Mines.

During 1909, several weeks were devoted to a further study of the shale areas of Albert and Westmorland counties, which had been tested—to some extent, during previous years. In the eastern part of Albert county, it was ascertained that greater value than previously given was to be attached to several areas, owing to the fact that analyses of the thin-bedded or 'paper shales,' with which the black oil-bands are associated, showed that this variety, to which previously little value was attached as a source of supply for crude oil, was nearly equal in its contents of crude oil and ammonia gas to the black oil-shales tested in the previous examination. These well banded, paper or thin shales form a very large proportion of the shale areas of the old Albert Mines property, and the importance of this discovery can be realized from the fact that these thin shales have a thickness of not much less than 1,000 feet, the greater part of which is well worth retorting. Much of this shale can be raised and sent to the retort very cheaply, since the greater part of the mining can be done by open-cut or steam-shovel methods; while in the old dumps derived from the mining of the original albertite vein, many thousands of tons of high grade shale are found, a great part of which can be put through the retorts without further treatment. As large quantities of albertite are also found in the mass of the dumps, the value of the whole is greatly increased, since, by analysis, the albertite carries over 100 gallons of crude oil, and more than 60 pounds of sulphate of ammonia to the ton.

During the past winter, analyses of several samples of thin or paper shales were made, which illustrate fairly well the character of the greater portion of the mass of the shale deposit along Frederick brook: the nature and extent of which can be inferred by comparison with the development work in connexion with the mining of the main albertite vein. Thus, in the Albert mine, in which the mass of shale passed through was largely of the thin-bedded variety, and in which the great vein of albertite occurs with a thickness, in places, of nearly 17 feet, the principal shaft, at the west end of the area, reaches a depth of 1,250 feet, and from it drifts are sent off on both sides. The thin shale is, as a whole, highly bituminous, and beds of the black shales were encountered at a number of places, as can be seen from the material in the dumps and from the records of the several levels. From the bottom of the main

shaft, a tunnel was driven north for 500 feet, all in shale of high grade, in which a well-defined anticline was cut through at a distance of about 400 feet from the bottom of the shaft. The workings at other levels showed material equally as good. On the whole, the bulk of the shale traversed by the several levels and exploratory pits is of very high grade as a material for distillation, and probably but little inferior to the black oil-bands on which the original estimate of value was based.

To the south of Frederick brook, which traverses the area of the Albert mines, a second tunnel, known as Robertson's tunnel, was, several years ago, driven south for 350 feet in a further search for albertite. This tunnel started from near the level of the brook, and was run toward the hill on which the manager's house is built. The tunnel traversed, for the whole of the distance, rich, thinly-bedded oil-shale; and this material can be seen to constitute the greater part of the hill, which lies in this direction. As to the character of the shale forming this hill, it may be said that it ignites readily under the flame of a match, thus showing that the contents in hydrocarbons are very high throughout. Similar shales in enormous amounts can be seen on the several branches of Frederick brook, both to the south and west, and also on those from the north. The shales are then covered over unconformably by the great mass of greenish conglomerate so conspicuous on the road to Salem, and along the upper part of Peck creek. Well-defined anticlines can be seen at several points in these shales. In the western part of the area, near the foot of Caledonia mountain, they are overlain by beds of greyish oil-sands, which when opened up some thirty years ago, gave off large quantities of gas. In one of the old tunnels driven in this sandstone, small quantities of oil were encountered.

Analyses made by the Mines Branch of samples from the five principal beds of black oil-shale, both curly and plain, uncovered last year along Frederick brook, are as follows:—

| — | Crude Oil. — Imp. Gallons per Ton. | Sp. Gr. of Oil. | Sulp. Am. — Lbs. per Ton. |
|---|---|---|---|
| Bed No. 1. 6½ feet thick | 48·5 | 0·892 | 82·8 |
| " 2. 3½ " | 38·8 | 0·892 | 60·3 |
| " 3. 5 " | 45·5 | 0·891 | 48·0 |
| " 4. 4½ " | 43·5 | 0·896 | 56·8 |
| " 5. See below. | | | |
| " 6. 6 feet thick (interbedded with thin paper shale) | 27·0 | 0·895 | 49·1 |

Bed No. 5 consists of alternations of thin paper shales with hard thin bands, all apparently of excellent quality, and aggregating an unknown but very large thickness.

From samples of paper shale taken from Frederick brook near the north end of the large dump, at a well-defined anticline, were obtained the following results, with which are shown the results of analyses of oil-shale from Robertson's tunnel, and for comparison of a specimen of albertite:—

| — | Crude Oil. — Imp. Gallons per Ton. | Sp. Gr. of Oil. | Sulp. Am. — Lbs. per Ton. |
|---|---|---|---|
| Frederick brook | 40·8 | 0·892 | 41·0 |
| " " | 18·0 | 0·892 | 40·8 |
| " " | 33·5 | 0·890 | 47·0 |
| Robertson's tunnel | 32·5 | 0·885 | 33·0 |
| Albertite | 112·0 | Undt. | 65·4 |

## Taylorville and Dover Areas.

The bituminous shales exposed at the Albert mines are concealed from thence easterly to the shore of Petitcodiac river at Hillsborough by red marls, green conglomerates, etc., of lower Carboniferous age, with which are associated large deposits of marine limestone, and gypsum. Across the river, the rocks of the Albert shale series appear at Beliveau, but are covered over within a short distance by grey sandstones of the Millstone Grit. The shales, however, emerge from this covering near the west bank of Memramcook river at Taylorville, where they form good exposures on the Taylor and Adams farms, which adjoin the road leading across the river to Upper Dorchester station on the Intercolonial railway. There, on the west bank of the river, a well exposed section of the oil-shales can be seen, showing several faults and overturns. Their presence is also recognized in the bed of the stream at low water near the Upper Dorchester bridge. On the east side of Memramcook river, the shales outcrop along the road leading from Memramcook village to Dorchester, and are again covered over in this direction by marine limestone and red marls. Northward, the shales outcrop in force near Memramcook, and on the west side of the river at St. Joseph's college and village, whence, with a covering of Millstone Grit and lower Carboniferous, they apparently extend in a northwesterly direction to Downing creek near Dover on the Petitcodiac. In this direction the shales form the north side of a syncline, the south side of which appears at Beliveau village.

## Dover Shales.

The shales of Upper Dover ignite readily from the flame of a match, and should be valuable material for distillation. Samples from several points along Downing creek were collected by my assistant, and were mixed so as to give a fair average sample of the whole mass. The analysis of this mixed sample has been made by Mr. H. A. Leverin, of the Mines Branch, with the following result:—

| — | Crude Oil. — Imp. Gallons per Ton. | Sp. Gr. of Oil. | Sulp. Am. — Lbs. per Ton. |
|---|---|---|---|
| Average of four samples from west bank Downing creek........ .... | 27·2 | 0·921 | 29·5 |

## Taylorville Shales.

A series of samples from the Taylorville shales was collected last year, and submitted for analysis to Dr. Baskerville of New York, since at that time the distillation plant of the Mines Branch had not been completed. These samples were taken from four beds of black oil-shale, both the plain and curly varieties. The thickness of these seams or beds as measured was, in two cases, 22 inches, while the third had a thickness of 36 inches, and the fourth, one of 60 inches. The results of the analyses of these samples, as made in Dr. Baskerville's laboratory and kindly furnished me, were as follows:—

| — | Crude Oil. — Imp. Gallons per Ton. | Sp. Gr. of Oil. | Sulp. Am. — Lbs. per Ton. |
|---|---|---|---|
| Adams farm, Taylorville.......................................... | 43·0 | 0·900 | 93·0 |
| Taylor " " No. 1.......................................... | 48·0 | 0·910 | 98·0 |
| " " " No. 2.......................................... | 37·0 | 0·925 | 110·0 |

On the completion of the plant in the laboratory of the Mines Branch, Ottawa, a second series of samples was collected from these beds and analysed by Mr. Leverin, with the following results:—

| — | Crude Oil. — Imp. Gallons per Ton. | Sp. Gr. of Oil. | Sulp. Am. — Lbs. per Ton. |
|---|---|---|---|
| Adams farm, No. 1 | 42·3 | 0·897 | 96·5 |
| " No. 2 | 47·3 | 0 901 | 88·7 |
| Taylor farm, No. 1 | 46·8 | 0·902 | 85·0 |
| " No. 2 | 45·0 | 0·903 | 101·0 |

These black shale beds, like those of the Albert Mines, are interstratified with the thin, bituminous or paper shales. This location is about 1 mile west of Upper Dorchester railway station, and the same distance from a high water shipping pier on Memramcook river. The various bore-holes sunk in the area between the Petitcodiac and Memramcook rivers penetrated several beds of the oil-shales, and showed in several places the presence of interstratified beds of oil-sand with an appreciable quantity of crude oil at several points.

## Baltimore Shales.

The results of the examinations of the shales of the Baltimore area, and the analyses of several of the black sands as furnished by Dr. Charles Baskerville of New York, were given in the summary of last year. Further examination confirmed the statements then made as to the wonderful richness of the black shale beds of the Baltimore area and of the grey shales of the West branch of Turtle creek, especially in crude oil, an analysis of one of the grey beds from this locality yielding no less than 56·8 imperial gallons of crude oil; while the yield of ammonium sulphate was 30·5 pounds per ton, the specific gravity of the oil being 0·891. Samples of these shales were subsequently taken from fresh openings and tested in the laboratory of the Mines Department, with the following result:—

| — | Crude Oil. — Imp. Gallons per Ton. | Sp. Gr. of Oil. | Sulp. Am. — Lbs. per Ton. |
|---|---|---|---|
| Baizley | 54·0 | 0·895 | 110·0 |
| E. Stevens | 49·0 | 0 892 | 67·0 |
| Geo. Irving | 40·0 | 0 895 | 77·0 |
| West Branch (grey shale) | 56·8 | 0 891 | 30·5 |

The Baizley bed has a thickness of 6½ feet: 4 feet curly, the rest plain.

A tunnel was driven into the Baizley area from the level of the brook north of Rosevale post-office for several hundred feet in a southeast direction. The material on the dump shows that the tunnel for the greater part of its distance passed through heavy bands of black oil-shale, both curly and plain, all apparently of high grade as regards crude oil and ammonia, the quality not differing greatly from that already tested.

### Prosser Brook Shale.

A further test of the shale taken from Hayward brook, a branch of Prosser brook, some 4 miles west of Turtle creek, gave:—

| — | Crude Oil. — Imp. Gallons per Ton. | Sp. Gr. of Oil. | Sulp. Am. — Lbs. per Ton. |
|---|---|---|---|
| .... ..... ........ ........................................ | 30·0 | 0·895 | 75·0 |

### Pleasant Vale Shale.

A further examination of the shale outcrops of Coverdale river near Pleasant Vale, and of those at Mapleton and at Elgin, was also made. In these deposits the percentage of hydrocarbons appears to be much less than in those already described and, as a whole, too low to be of much value for distillation purposes; although in physical features, their resemblance to the bituminous shales of the Albert series is easily recognized. At Pleasant Vale, the shale deposits were opened to some extent during the period when the Baltimore and Westmorland shales were exploited, nearly fifty years ago. A tunnel is reported to have been driven in the bank of shales on the east side of Coverdale river for some 140 feet, and a shaft was sunk on the west side of the stream to about 20 feet. It is also reported that the shales of this area were sufficiently rich in hydrocarbons to kindle readily with a match flame, and that small veins of albertite were found. A later examination of these shales was made, but they did not promise to be sufficiently rich in hydrocarbons to warrant a complete analysis being made.

### Mapleton and Elgin Shales.

Westward through Mapleton the shale is exposed at a number of places following along the main road between this place and Elgin corner. Samples were collected south of Parkindale on the James Prosser farm, but here the shale appeared to be too sandy and lean to be of much economic importance. Several samples were, however, collected, and the analyses by Mr. Leverin showed the amount of crude oil to be only 4 imperial gallons per ton, with a specific gravity of 0·891. The shales of the area extending through Mapleton were not deemed sufficiently rich to warrant analysis; but at Bannister brook, where in 1876-7 much work was done by tunnelling and boring, samples were collected which gave, on analysis, 14 gallons crude oil per ton, with specific gravity, 0·893. This place is about 2 miles east of Elgin corner.

### Goshen Shale (Montgomery Hollow).

The same lean character appears to affect the shales west of Elgin along Robertson brook; but on Montgomery brook near Goshen, which is 3 miles west of Elgin corner, beds of bituminous shale are exposed which appear to be much richer in hydrocarbons than those seen elsewhere in this area. Samples were selected, and on analysis by Mr. Leverin yielded:—

| — | Crude Oil. — Imp. Gallons per Ton. | Sp. Gr. of Oil. | Sulp. Am. — Lbs. per Ton. |
|---|---|---|---|
| ... ............ ... ................................... ..... ... | 27·5 | 0·897 | 36·0 |

### Sussex and Norton Shales (Kings County).

All the shales occurring south of Sussex and thence west to Norton, that were examined during the past season, appear to be so lean in hydrocarbons as to be valueless for distillation. Samples were frequently tested in the field, but none would kindle even with strong heat, though, in several cases, there was a slight smell of bituminous matter.

These lean shales are well exposed along the road running south for some miles up Wards creek, or almost to Wards mills; and, going west along the road to Campbells corner by way of Ratters corner, frequent outcrops are seen. Along the course of Moosehorn brook, which shows an interesting section of the rocks of this formation from the line of the railway to Campbells corner, the bituminous shale is not well defined; but the shales are again seen on a road leading southeast from Bloomfield station until they are terminated in this direction by great ledges of the red Perry conglomerate.

## OIL-SHALES OF NOVA SCOTIA.

Prior to the work of the past season, much of the information possessed by the public relative to the oil-shales of Nova Scotia was obtained from the examination made by Mr. J. Campbell, whose results were contributed to the Mineralogy of Nova Scotia, published in 1868 by Dr. Henry How. As this publication did not give the exact distribution of the several oil-shale areas nor the analyses of the various deposits, it was deemed best to take up this aspect of the question and to ascertain, as far as possible, the actual value of these shales as regards their contents in crude oil and ammonia gas. The areas are indicated on maps by the late Mr. Hugh Fletcher, published by the Geological Survey. Large and representative samples of the various shales, many of which had not been previously examined, were collected, especially from the counties of Antigonish and Pictou.

Attention was first given to the deposits of shale found along the Avon river, at Hantsport and Horton, Cheverie, Walton, etc., all of these areas belonging to the same geological formation, and the sediments being of the same general character. The oil-shales of this area were mentioned in How's Mineralogy of Nova Scotia (1868), and were thought to also outcrop at the village of Newport, on the line of railway between Windsor and Halifax, a few miles east of the former place. In all the places named above, black shales are abundant, but are carbonaceous rather than bituminous.

### Hantsport and Horton Shales.

In bore-holes for coal put down a few years ago near Hantsport, a depth of 1,500 feet was reached, and though no regular log is now available, it was ascertained from information obtained from one of the drillers who had charge of the work at that time, that the formation passed through for the first 600 feet was a greyish sandstone. This passed down into a black carbonaceous shale, and at 800 feet the drill was reported as cutting 10 to 12 feet of black oil-shale. Below this the drill is said to have passed through sandstone and non-bituminous greyish shale. The specimens obtained from the reported oil-shale band are said to have burned readily when exposed to a flame, but at the time of our visit, no specimens could be obtained for analysis, though large pieces of the core taken from the grey, sandy portion occur in the vicinity of the boring. Along the banks of several brooks, cliffs of grey and black shales were seen and carefully examined, but no beds of oil-shale of commercial value were found at any point in the vicinity. Ledges of a hard, white sandstone, almost a quartzite, occur, with black and grey shale holding numerous plant remains. Some parts of this shale are reported to burn readily, and are quite carbonaceous. None of the samples examined by us were, however, capable of being ignited in an ordinary flame.

The carbonaceous black shales, which occur along the beach between Hantsport and Horton bluff, are regarded as of the same geological horizon as the Albert shales of New Brunswick. They were carefully tested for several miles along their outcrop, and sampled by means of the usual field tests for bituminous shales, but without any promising result, the splinters of the shale not even igniting with a strong flame, though their flaggy, fossiliferous character is pronounced.

## Cheverie and Walton Shales.

On the whole, it may be said that the sediments about Hantsport and thence north to Horton bluff resemble closely those extending eastward from the mouth of the Avon, between Cheverie and Noel, good sections being seen along this part of the shore east from the mouth of the river for some miles. The black shales and associated beds at Split rock and thence to Walton are often very black, but are carbonaceous rather than bituminous, though several thin bands are reported as being exposed at low water on the beach at Cheverie, and are said to ignite. Their exposed volume must be small, however, since along this part of the shore they are capped directly by masses of plaster and marine limestone of lower Carboniferous age, in which traces of crude petroleum are found. These reported oil-bearing shales were not visible during the time of our visit to this locality. They do not appear to possess much economic value.

## Lochartville Shales.

In the vicinity of Lochartville, several miles northwest of Hantsport, oil-shales were also reported to occur. On examination, black, carbonaceous beds, with grey sandstone and grey and bluish shales, were found at several points. Several bands of these were said to ignite and burn readily, but in a close examination of this area no such rocks were observed. Several shafts and bore-holes have been sunk in these sediments, presumably for coal, but nothing of economic value has yet been discovered.

## Newport Shales.

Two areas near Newport, east of Windsor, are supposed to be part of the shales described in How's Mineralogy, 1868; but a somewhat close examination of the district showed the shales there exposed to belong, in part, at least, to the black carbonaceous variety, and, in part, to be hard, altered shales with quartz-veins; nor could any of the residents of that locality who were interviewed, give any information as to where bituminous shales, such as had been described as occurring there, might be found. A small shaft was sunk some years ago in the black carbonaceous shale, apparently in a search for coal, as the place is still locally known as the 'coal mine,' but nothing of the nature of a true oil-bearing or bituminous shale was observed.

While, therefore, from the testimony of several residents of this part of the Province, it would seem that certain bands of bituminous shale exist in the shale formation of the area about the mouth of Avon river, thus confirming to some extent the statement of Mr. Campbell in How's Mineralogy, it must be said that in our examinations of the past season no person could be found who could indicate where bands of oil-shale could be located.

## Shales East of Parrsboro.

Crossing Minas basin to Parrsboro and going east to Moose and Harrington rivers, large ledges of black and grey shales were observed on these streams, on several other brooks, and also along the roads from Parrsboro to Five Islands. At the crossing of Moose river there are cliffs of greyish and black shale, some portions of

which are quite black and carbonaceous. All are highly inclined, often much folded, and without much indication of bituminous matter. On the whole, they are like the rocks of the lower Avon just described. As a rule, greyer beds predominate over the black and hold interstratified beds of hard sandstone, sometimes quite quartzose, and like those in the vicinity of Hantsport. The rocks are generally steeply inclined, sometimes at angles of 75° to 90°. They are often splintery or pencil-shaped, a structure induced evidently by pressure. The series as a whole, in so far as examined at a number of widely separated points, is but slightly bituminous. Similar shales outcrop in the vicinity of Parrsboro village, but no bituminous shales of the aspect or type of the Albert shales were seen at any point in the area.

### Shales of Truro and Onslow.

An examination of the shale deposits near Truro and vicinity, as seen along the North river in Onslow and the streams flowing from the south side of the Cobequid range, shows them to be very similar to those of the Avon river just described. The shales are generally hard and dry looking, varying in colour from grey to reddish-brown and black, with hard, sometimes quartzose, greyish sandstone. So far as examined, the series appears to be largely non-bituminous, the black portions being of the carbonaceous variety, like those already described elsewhere. No trace of oil-shale was observed in this series, which extends along the south side of the Cobequid mountains for some miles. In places, as on Debert river and at Cottam settlement, small seams of coal are found, generally too thin, impure, and dirty to be of much economic importance. They resemble in some respects the seams found at Hallowell Grant in Antigonish county, the rocks of both places being apparently of the same geological horizon. In all places where the rocks of this formation are found, they are unconformably overlaid by the limestones of the lower Carboniferous. The black carbonaceous shales of the North River district occur in large cliffs along the stream, and it was hoped that a careful examination of this area would have shown some indication of the bituminous or oil-bearing series of New Brunswick, to which horizon they seem to belong. So far our expectations in this direction have not been realized.

### Shales of Pictou and Antigonish Counties.

Farther east, in the counties of Pictou and Antigonish, both carbonaceous and bituminous shales occur in large quantity. The formation in Pictou was very fully described by Sir William Logan and Mr. E. Hartley, in the Geological Survey Report published in 1869, a book long out of print. During the past season, the principal outcrops there mentioned were carefully investigated, and large samples were collected for analyses by the Mines Branch in order that their contents in crude oil and ammonia gas might be ascertained.

### Shales of McLellan Brook, Pictou County.

The principal development of the shales in Pictou county is along McLellan brook, south of New Glasgow. This stream is a branch of the East river of Pictou, along which, in this area, the shales are also exposed in a series of cliffs often of large extent; they also appear on several other branches, notably on Shale and Marsh brooks. The greater part of the shales are of the black or carbonaceous variety rather than the bituminous, but large quantities contain sufficient hydrocarbons to ignite readily in the flame of a forge, in which a number of them were tested in the field examination. At a point on McLellan brook known as the old Fulling mill, the shales are associated with oil-shales which closely resemble the stellarite found in the Acadia Coal Company's areas at Stellarton, described by Sir William E. Logan in the Report for 1869.

Eight samples, to make a good average test of the shales of this area, were collected from points along the main stream and from other outcrops adjacent. The results of the analyses of these, made by Mr. Leverin, are given below. Sample No. 1, taken on McLellan brook, is from Patrick's slope, a short distance below the old Fulling mill; the area is affected by faults; the width of the bed, in places, is as much as 8 feet, but, in the old workings, in places, is a few inches only:—

| — | Crude Oil. — Imp. Gallons per Ton. | Sp. Gr. of Oil. | Sulp. Am. — Lbs. per Ton. |
|---|---|---|---|
| No. 1. McLellan brook | 42·0 | 0·889 | 41 |
| No. 2. " " (near Black's old mill site) | 14·5 | 0·892 | 35 |
| No. 3. Marsh brook, tributary from the east, lower end | 8·0 | Undt. | Undt. |
| No. 4. 150 feet above McKay's house | 3·0 | Undt | Undt. |
| No. 5. Marsh brook, 300 feet above McKay's house | 14·0 | 0·903 | Undt. |
| No. 6. Shale brook, tributary from west, near forks with main brook | 9·0 | 0·921 | Undt. |
| No. 7. Shale brook near upper end of brook | 4·0 | Undt. | Undt. |
| No. 8. One mile west of Woodburn station, on small brook, and 500 feet north of railway track, bed of shale 10 feet thick | 14·3 | 0·902 | Undt. |
| No. 9. Stellarton, stellarite from old dump | 44·8 | 0·875 | 14·5 |

The original description of stellarite, given in Logan's and Hartley's report, 1869, shows the amount of crude oil to vary greatly at different points in the shale bed, ranging from 45 to 130 gallons per ton; apparently no tests for sulphate of ammonia were made at that time.

## Antigonish Shales.

In Antigonish county an examination was made of the shale and coal deposits found at Big Marsh or Hallowell Grant, about 9 miles north of the town of Antigonish. This was one of the areas described by Mr. Campbell in How's Mineralogy of Nova Scotia, 1868. Both the plain and curly shales were found in considerable quantity, and eight samples were collected from various points in the field. These have been thoroughly tested in the laboratory of the Mines Branch by Mr. Leverin.

The Big Marsh (Dan McDonald's) location is situated near the corner of the road beyond the post-office, about 9 miles from Antigonish station on the Intercolonial railway. The deposit was opened about 45 years ago by a shaft, sunk to a reported depth of 60 feet, of which the upper 40 feet is said to be in a plain, black carbonaceous shale. The lower 20 feet of the shaft is said to be in a black, curly shale, portions of which ignited quite readily. Samples of both varieties were collected. On testing in the field, the black, plain, carbonaceous variety kindled with difficulty in a stove with a strong draft. The curly variety on examination proved to be for the most part a carbonaceous shale containing only a small amount of crude oil, the analysis in the laboratory giving only 4·8 gallons, and of sulphate of ammonia, 8·7 pounds, per ton. This part of the deposit, therefore, has but small economic value.

On the road east to the shore of George bay, black shales are well exposed at a number of points. These were all examined. On both sides of the post-road near Big Marsh post-office, outcrops of black carbonaceous shale occur, with other beds which are greyer, siliceous, and micaceous. Near the post-office there is a seam of dirty coal from 5 to 8 feet thick, which has been opened to a small extent. Samples of this analysed in the laboratory show the percentage of ash to be so large as to render the

coal practically unfit for fuel, the amount of ash being 45 per cent. The associated shales are apparently devoid of hydrocarbons, the black portions not igniting even under a strong flame.

Other outcrops of the black carbonaceous shales of this formation are seen for several miles along the road toward Antigonish; but these, while very black, would not ignite even under the flame of a blow-pipe. They contain plant stems and fish scales, the fossil *Lepidodendron corrugatum* being fairly conspicuous. They resemble the shales found farther west, at Avon river and near Truro. No analyses were made of the shales associated with the coal seams of this place, since their general character was so unfavourable.

Going east from the corner near Big Marsh post-office, a small stream known as McLellan brook crosses the road and shows ledges of black shale, both the curly and plain varieties. Samples of these were taken, which were analysed by Mr. Leverin, the results being, for the curly portion, 6 gallons of crude oil per ton, while the plain shale gave neither crude oil nor sulphate of ammonia. On Sawmill brook, a short distance east of John Boyd's house, large outcrops of very black and greyish shales, both of the plain and curly varieties, are found, forming cliff-like banks with an elevation of 100 feet or more. These were tested at a number of points, and gave the most favourable returns of any of the shale deposits found in this area. At a place known locally as the 'Banks,' from which the timber has been largely burned, the shale, of which the banks are composed, was ignited several years ago, kindled probably by a bush fire, and continued to burn for many months. The shale thus exposed appears to be comparatively rich in hydrocarbons, and shows a very large development along this part of the stream. An analysis of the shale from this area is given below:—

| — | Crude Oil. — Imp. Gallons per Ton. | Sp. Gr. of Oil. | Sulp. Am. — Lbs. per Ton. |
|---|---|---|---|
| The "Banks" | 11·0 | 0·917 | 22·6 |
| Sawmill brook—curly shale | 10·0 | 0·893 | 38·0 |
| Sawmill brook—plain shale | 23·6 | 0·906 | 34·0 |
| " " | 10·0 | 0·890 | 17·0 |

It would appear from the results of these analyses, that portions of the immense quantities of shale exposed at this place might be profitably mined, since the returns both from the plain and curly varieties are good both in crude oil and ammonia. The fact that these samples were taken from near the surface, and may have been affected by the burning which devastated the area, leads to the belief that, possibly, samples taken from deeper excavations might give, on analysis, better results.

Farther east, at what is known as the Beaver, near the shore road, considerable areas of very black, carbonaceous shales occur. These, some years ago, had been opened by small pits at several points; among other places, on the land of Mr. Hugh McInnis. The shales at this place are jet black, and contain in some layers an abundance of plant stems and fish scales. The yield of these shales in the laboratory gave of crude oil, 7·45 gallons per ton; the amount of sulphate of ammonia was not determined. The horizon of these shales seems to be the same throughout the area.

### Cape Breton Island.

The rocks about Hastings on the east side of the Strait of Canso, and thence north for some miles, are apparently of the same series as those of Antigonish just described, and, like them, are unconformably overlain by lower Carboniferous limestone and gypsum. No shales of a bituminous nature were anywhere observed, though such shales may exist at some points inland, concealed by overlying formations. The only deposits in Cape Breton, so far known, are those of McAdam lake, which were described in last year's Summary Report. They are not, as far as they have been tested, oil-bearing to any marked extent.

## OIL-SHALES OF GASPÉ, QUE.

In August, accompanied by my assistant—Mr. S. C. Ells—a visit was made to Gaspé basin, to examine the reported occurrences of oil-shales in that part of Quebec. In this work traverses were made along several of the rivers for considerable distances, the area cursorily examined being not far from 300 square miles, or 30 miles in length by 10 miles in width. The reported oil-shales, which are rather of the nature of a resinous, shaly sandstone, occur in the vicinity of the village of Gaspé and along the York and St. John rivers, which flow into Gaspé basin. These oil-bearing rocks were referred to in the report by Sir W. E. Logan on this country, 1843-4. The presence of several oil springs in this area was also pointed out by Logan, and subsequently many thousands of dollars were expended in boring operations for oil. The companies principally engaged in this work were: the Petroleum Oil Trust of London, England; the Canadian Petroleum Company of Manchester, England; and the International Oil Company of Minneapolis, U.S.A. In all, more than fifty wells were sunk in the Gaspé area, several of which reached a depth of over 3,500 feet. A description of the geological structure of this district, with an account of the various borings and an unabridged record of most of the logs, was given in the Summary Report for 1902.

The so-called oil-shales are quite distinct in character from those of New Brunswick and Nova Scotia already described. They belong to the upper Devonian, and are of the nature of greyish sandstones, which are shaly in places. These rocks contain layers of plant remains, among which *Psilophyton princeps* is particularly abundant, and certain beds of the shaly rock are almost made up of the remains of this fossil.

The possibility of the future economic value of these shaly rocks about Gaspé was alluded to by Sir W. E. Logan in his early report above noted. It was found that the oils obtained by boring were of two kinds, viz., a light-amber coloured oil which was obtained chiefly from the upper or sandy portion of the formation, and a dark-green, heavier oil which was obtained from the calcareous, underlying rock, which apparently was more closely allied to the upper Silurian. The upper or sandstone series, represents what is known as the upper portion of the Gaspé Devonian. The layers which show the plant remains most abundantly are greyish-black in colour, kindle readily when a lighted match is applied, and burn with a strong, yellow flame. These beds are heavily charged with a black or sometimes yellowish resin, which appears to represent the gummy portion of the plants. The residue after ignition is almost a pure, greyish, quartz sand.

Large samples of these sandy oil-shales were collected at a number of points, and have been analysed at the Mines Branch by Mr. Leverin. Three samples were chosen for analysis, of which two were from York river and one from the St. John near Law brook. The results of the analyses are as follows:—

| — | Crude Oil. — Imp. Gallons per Ton. | Sp. Gr. of Oil. | Sulp. Am. — Lbs. per Ton. |
|---|---|---|---|
| St. John river, on Law brook :— | | | |
| No. 1. from band 14 inches wide.......... .... . ............. | 30·0 | 0·962 | 42·20 |
| No. 2. " 5 inches " Oil tarry.......... .. ..... .... | 31·5 | 0·977 | 40·00 |
| No. 3. from loose piece on York river, pieces large and numerous | 36·0 | 0·953 | 59·50 |

The principal places where the oil-shales occur in Gaspé, as observed during the past season, are mentioned in the following descriptions. At the site of Shaw's old mill (now demolished) in the west part of the village of Gaspé Basin, where ledges of grey sandstone with associated grey shales outcrop, portions of the sandstone are shaly and contain an abundance of plant stems, apparently for the most part of *Psilophyton*. The outcrops near the mill site are now largely obscured by debris, so that the beds rich in hydrocarbons are concealed. The thickness of the oil-bearing sediments at this place, as seen and described by Logan, was from 12 to 15 inches, and the outcrop was traced for a distance of about 200 feet, until covered by the overlying sandstone.

Referring to the presence of bituminous matter in these rocks of Gaspé, Logan remarks[1]: 'Some beds of these rocks contain, besides, a peculiar resinous matter, which forms the cementing material. It appears on the fractured edges of the beds, in the form of irregular laminæ rarely an eighth of an inch in thickness, and generally much less. It has a vitreous lustre, a conchoidal fracture, and is tough, with a hardness nearly equal to calc-spar. Its colour is deep reddish-brown, but it gives a fawn-coloured powder, and when in thin plates or fragments is translucent, and has an orange-red colour. The substance has neither taste nor odour; it is insoluble in alcohol, naphtha, or potash lye, and is but slightly attacked by nitric acid. It is scarcely fusible; but at a high temperature is decomposed, with a slight softening and swelling up, giving off abundance of inflammable vapours, and leaving a small quantity of brilliant spongy coke. It has the appearance of fossil resin, something like amber, but in its general characteristics approaches more nearly to what have been named schleretinite and middletonite.

'The portions of the sandstone impregnated with the resin burn when kindled, with a brilliant flame and much smoke, and the residue which consists chiefly of siliceous sand has very little coherence. Partial analyses were made of four fragments of this rock which were supposed together to represent an average of the mass. The amount of volatile matter, of fixed carbon or coke, and of the incombustible residue was as follows:—

| — | I. | II. | III. | IV. |
|---|---|---|---|---|
| Vol. matter.............. ... . ............... .. ..... | 32·4 | 22·8 | 42·8 | 30·4 |
| Carbon.. .. ......... ........... ..................... | 8·9 | 8·1 | 7·4 | 8·9 |
| Residue................... .................... ..... | 58·7 | 69·1 | 49·8 | 60·7 |
| | 100·00 | 100·00 | 100·00 | 100·00 |

1 Geol. Canada, 1863, p. 791.

'The purest specimen is seen to yield the smallest amount of fixed carbon. The excess of this in others is due, in part, to the small portions of mineral charcoal generally present among the layers of this resinous sandstone. The material could be made to furnish large quantities of illuminating gas and lubricating oils, by a process of distillation similar to that applied to coal and bituminous shales. In some experiments made on a small scale to test its powers of producing illuminating gas, it was found that a few pounds of this material, which lost by distillation 26 per cent of its weight, yielded 2¼ cubic feet of gas of superior illuminating power, to the pound. As this quantity of volatile matter corresponds to about 33 per cent of resin, it is evident that if obtained in a state of greater purity this material would become valuable as a substitute for coal in gas-making.'

The specimens from which the preceding analyses were obtained were taken from the bed in the vicinity of Shaw's mill already referred to. An examination of the shore of the York river was made for some miles up-stream, and although the sandstones of the formation could be traced at intervals, for a long distance, the presence of the resinous sandstone portion was not seen in place along the lower part of the stream, though large, loose pieces, evidently from a bed of this substance in the near vicinity, were found along the beach and in several small streams flowing from the hills to the north and cutting across the measures. About 3 miles above Shaw's mills, the blocks of this resinous shale were large and numerous along the beach, also in the bed of a small brook; but owing to the large covering of drift the position of the bed from which these pieces were derived could not be determined.

By means of a canoe, a traverse was made by my assistant up the York river for nearly 30 miles, in which distance bands of the resin-bearing shaly sandstone were seen at a number of places. Owing to the prevailing rainy weather during this trip, the examination of the several beds was necessarily curtailed to some extent, but the bands were found to be from 4 to 12 inches in thickness, extending in lenses, sometimes for 100 feet. Of these bands Sir W. E. Logan says:[1] 'Some of them are composed in great part of laminæ of a brilliant brownish-black matter; which when examined in thin fragments show the same reddish translucency as the resin just described, and are apparently similar to it in composition; although in some cases mingled with more coaly matter and containing less ash. A specimen from one of these beds on the York gave of volatile matter, 52·4 per cent; carbon, 26·3 per cent; residue, 21·3; total, 100·00. The greater portion of volatile hydrocarbons which may be obtained from this would render it still more valuable for distillation than the bed whose analysis has been given above. These curious deposits are evidently worthy of future study from an economic point of view.'

A brief report on the results of this recent trip of my assistant up the Gaspé rivers is here given, and confirms, to a large extent, the views stated in the Geology of Canada, 1863, already quoted.

With the exception of the statements already quoted, practically nothing definite was known as to the occurrence of oil-shales anywhere in the Gaspé peninsula. The results here given are of a six days' trip up the York river, along the lower part of the St. John, and of the stream flowing into Seal cove, farther south. The several samples collected may be considered as representing the best quality of the oil-bearing bands found in the eastern Gaspé district, though several outcrops of inferior quality were also noted.

Owing to the rapid rise in the streams, due to numerous rapids and small waterfalls, the thickness of the shales in which hydrocarbons might be looked for, could not be definitely ascertained, but it embraced several hundreds of feet. Several streams, including the Dartmouth, York, St. John, and Seal cove, all flowing into Gaspé basin, were traversed, the distance varying according to the development of the underlying

[1] Geology of Canada, 1863, p. 792.

Silurian formations. Thus, on the south side of the Lower Dartmouth, which flows into the north arm of Gaspé basin, grey sandstone and shales appear in almost continuous ledges westerly from the village of Gaspé Basin, the dip for this portion being northerly, and the axis of an anticlinal at the village following along the north side of York river. Along the south side of the Dartmouth, approaching Calhoun's mills, the grey sandstones pass up into reddish beds; while on the north shore, the ledges have a southwesterly dip, showing the presence of a synclinal along this part of the stream. The rocks along the north shore seem to represent, in part, the portion of the formation which passes from the Devonian into the upper part of the Silurian. Westward on this stream, igneous rocks, including serpentine as at Ladysteps brook, appear, and the underlying Silurian occupies the valley from a short distance above the falls of the Dartmouth. No trace of the oil-shales was seen on this lower part of the river.

The York river was ascended to a point a short distance above Falls brook, or about 30 miles above the mouth at Gaspé village. The St. John river, which is the next to the south, was ascended to a point about 3 miles west of Law brook, or well into the area occupied by the Silurian, and the Sealcove river to a distance of about 6 miles from its mouth. On this last stream, owing to the generally low and swampy nature of the banks, rock outcrops were rarely seen, so that in this direction nothing as to the economic value of the shales could be ascertained. Several tributary streams were also traversed, in all of which indications of the resin-bearing shales were observed either as drift or in place. The area of country from which samples, considered to be typical of the oil-bearing strata, were collected, is about 150 square miles.

In all, some twenty-three small seams were found, ranging in thickness from 1 inch to 5 inches. A more extended examination of the district would, probably, show double the number. These thin beds sometimes unite to form zones. Thus, on St. John river near Flat Rock, zones of 5 to 8 feet carry numerous thin bands of the resin-bearing shale separated by sandy partings. Of these small bands, the heaviest appear to be about 13 inches in thickness. None of the outcrops seen at this place or elsewhere would seem to warrant much expenditure in development work; but if analyses indicated high contents in hydrocarbons, then further detailed examinations, either on the surface or by the aid of a light drill, would seem to be advisable.

The sandstones along the lower York and St. John rivers show the presence of three main anticlines, the strata, for the most part, being inclined at angles of less than 30°; but in places the angle of dip is much higher. Through these sandstones, fossil plants are generally widely distributed, and accumulations of these organic remains appear to have given rise to the bituminous matter and the contained hydrocarbons. Unlike the oil-shales of New Brunswick, in which the oil appears to be a chemically combined constituent of the shales, the oil in the Gaspé shaly sandstone occurs often in the form of hardened patches of bitumen, sometimes in appearance resembling albertite, and distributed in greater or less amount as a physically combined constituent of the sandstone. It was also noted that in the more massive beds of the sandstone, the layers are of larger size and of apparently richer quality than in the thinly laminated sandstone.

Regarding the oil-shale or resin-bearing bands, irregularity both in thickness and in longitudinal extent constitutes a very serious feature. In fully 50 per cent of the outcrops seen, they pinch out within a distance of 150 feet, forming lenses rather than uniform beds or seams. In other cases, the beds split up into very fine narrow bands of an inch or even less in thickness within a distance of not more than 200 feet, thus showing the rapidity with which such changes may be expected. It is difficult to say whether conditions favourable to the formation of heavy seams would be also more favourable to greater uniformity as to thickness and quality..

From the evidence obtained in this brief reconnaissance, the conclusions so far arrived at relative to the occurrence of deposits of oil-shale of commercial value in the Gaspé basin cannot be regarded as favourable, though careful prospecting of detailed character may lead to the discovery of seams of oil-bearing rock of more promising dimensions.

In the event of such prospecting being attempted, the following suggestions may here be given. The rivers are easily navigable by poling in canoes, and on these streams and on some of the small branches, practically all the rock exposures of the region may be found. In many cases, cliffs, 25 to 125 feet in height, either skirt the shores or are found at a distance of a few yards back from the shore-line. Considering the many low-lying ledges, the season of low water, including the months of July and August, will obviously be the most favourable period for prospecting. The oil-bearing bands are difficult to distinguish from the bed-rock proper at a distance of more than a few feet, thus making a traverse on foot of each shore practically a necessity.

# BATHURST DISTRICT, NEW BRUNSWICK.

*(G. A. Young.)*

## INTRODUCTION.

The field season of 1909 was spent in the neighbourhood of Bathurst, N.B., with the object of extending southward the mapping of an area commenced in 1908. During the first season there was mapped a strip of country running south from Chaleur bay along the west shore of Nipisiguit bay, measuring about 18 miles long, with an average width of 8 miles. During the past season, 1909, a contiguous area of about 150 square miles, lying immediately south, and including the town of Bathurst at the mouth of Nipisiguit river, was topographically and geologically surveyed. An additional area of about 1 square mile, situated south of the limits of the map-sheet and surrounding the Nipisiguit iron deposit, was surveyed in detail.

The Bathurst district is important because of development work in progress in connexion with deposits of iron ore lying some 15 miles inland, to the south of Bathurst. It was hoped to extend the map-work sufficiently far south to embrace the area in the immediate neighbourhood of the ore bodies; but the comparatively slight vertical relief, and the heavily wooded character of the wholly unsettled country in the southern part, made progress so slow as to prohibit the accomplishment of this aim. Instead, the general map-sheet work was continued inland to latitude 47° 30′, or about as far south as Pabineau falls on Nipisiguit river; and a small detached area immediately surrounding the iron deposits was mapped in detail.

The examination of the geology of the district was carried out by the writer; while the work in connexion with the topographical surveying was entrusted to a number of student assistants, all of whom performed their duties in a painstaking and highly satisfactory manner. Mr. W. E. Lawson—assisted by W. L. Uglow, H. W. Fleming, N. C. Macrae, and A. G. McIntyre—was placed in charge of the transit-chain control work. Mr. D. A. Nichols—assisted by A. Boucher—took charge of the plane-table-stadia traverses of roads and streams. Mr. B. Rose—assisted by J. L. Cavanagh—sketched in contours with 50 ft. intervals, by meandering traverses run by plane-table, compass, tape, and aneroid. All plane-table work was done on a scale of 1/48000.

The district mapped during 1909 lies at the junction of the regions shown on two geological maps prepared by R. W. Ells and published by the Geological Survey.[1] The results of a magnetometric survey of the Nipisiguit iron field have been issued by the Mines Branch.[2] A description of the iron deposits has been given by Mr. J. E. Hardman.[3] References to the geology of the district occur in some of the older reports of the Geological Survey; in publications of the provincial government; in 'Acadian Geology,' etc., etc.

## GENERAL CHARACTER OF DISTRICT.

The district lies along the northeastern edge of the rugged country of central and northwestern New Brunswick where this relatively elevated region is bordered by the comparatively low, almost flat, Carboniferous area of the eastern part of the

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1 Sheet 3 S.E., Bathurst Sheet, Scale 4 miles to 1 inch, and Sheet 2 N.E., Newcastle Sheet, Scale 4 miles to 1 inch; accompanying reports, Part D and Part DD, Ann. Rept. Geol. Surv. Canada, 1880-1-2.

2 Magnetic Survey, Austin Brook, Gloucester Co., N.B., by E. Lindeman.

3 Hardman, J. E., 'A new iron ore field in the Province of New Brunswick,' Jour. Can. Min. Inst., Vol. XI., 1908, pp. 156-164.

Province. Within the limits of the sheet, the north-flowing Nipisiguit river approximately marks the boundary between these two contrasting types of country. On the east, the nearly level, slightly rolling country, underlain by practically horizontal Carboniferous strata, gradually rises from the sea to a height of about 270 feet. West of Nipisiguit river, over the area occupied by highly folded and faulted pre-Carboniferous strata and invading igneous bodies, the land rises more rapidly to a maximum height of slightly over 700 feet above the sea.

West of the Nipisiguit, the contours pursue generally, north and south courses, but swing far up the often gorge-like valleys of the easterly-flowing streams and rivers tributary to the Nipisiguit. In a number of instances these ravine-like waterways are particularly striking, as in the case of that of the Tetagauche river, the waters of which are confined to a narrow, trench-like depression seldom more than 200 feet wide, with steep, often almost vertical walls rising 75 feet to 200 feet above the river bed. But, except in the immediate neighbourhood of the larger waterways, the country is broadly rolling, with only an occasional outstanding hill. Save for the stream valleys, the surface of the country is a tilted plain rising from the Nipisiguit valley, with a fairly even westerly gradient.

## GENERAL GEOLOGY.

The two contrasting types of country east and west of the Nipisiguit are, geologically also, sharply differentiated. East of the Nipisiguit the country is underlain by almost undisturbed, reddish, fine conglomerates, sandstones, and shales of Carboniferous (Millstone Grit?) age. West of the river, the rocks are largely early Palæozoic (Ordovician?) sediments, chiefly black slates and grey sandstones and slates, closely folded and faulted, and in places, schistose. They are penetrated by dike-like bodies of igneous rocks, and to the south and west of Bathurst by a large body of granite that disappears eastward beneath the younger Carboniferous strata.

The country, as a whole, is very unfavourable to the study of geology. Save along the beds of a few of the larger streams, exposures are usually wanting. Over square miles of country, no rock *in situ* appears, the underlying formations being largely hidden by morainic and other material of glacial origin. Because of this general lack of exposures and the highly folded attitudes of the beds west of the Nipisiguit, it is not possible to offer an entirely satisfactory classification of the sedimentary rocks or to determine with certainty their ages. The following tabular list of formations is, therefore, but an imperfect one:—

### QUATERNARY.

Stratified clay, sand, and gravel.
Glacial till, morainic deposits, etc.

### PALÆOZOIC.

*Carboniferous*—
Bathurst formation.

*Devonian?*—
Bonaventure formation.
Nipisiguit granite.

*Post-Ordovician*—
Basic dikes.
Austin Brook quartz porphyry.

*Ordovician*—
Black shales, sandstones, etc.

*Ordovician, Black Shales, Sandstones, etc.*—Along nearly the whole course of the Tetagauche river, and at intervals in the beds of Little and Middle rivers, are numerous exposures of tilted and faulted, black, often highly graphitic slates, in many places accompanied by broken or torn bands of fine, dark sandstone. With the dark beds, also occur one or more zones of brick red, hardened, argillaceous or fine, arenaceous, slaty beds. Though rarely seen in the intervals between the main streams, these dark slates, etc., doubtless occupy nearly the whole of the country east of the Nipisiguit, excepting the portion underlain by the batholithic area of Nipisiguit granite. To the south, beyond the limits of the map-sheet and south of the granite body, the dark slates and associated beds reappear along the Nipisiguit, and are there intruded by the Austin Brook quartz porphyry, with which are associated the Nipisiguit iron deposits.

In places, the slates are schistose, apparently both along zones of shearing, etc., and in the neighbourhood of the granite batholith. The strata are closely folded, the strike, in general, being east and west, and the dip often nearly vertical. Quartz veins are common, and are very numerous in narrow zones. At many places, the rocks are impregnated with pyrite, often to a high degree.

Fossils were found in these beds at only one locality, on the Tetagauche, near the crossing of the Intercolonial railway, where imperfectly preserved graptolites occur. A collection of these graptolites made by an earlier observer, was examined by H. M. Ami, who stated that the enclosing shales 'appear to be . . . . homotaxial with the shales of Norman Kiln, near Albany, N.Y. . . . . ;[1] that is, with the lower Trenton.

On the several rivers already enumerated, appear comparatively narrow zones of fine tufaceous conglomerates, sandstones, and shales, all grey in colour, and closely enfolded with the dark slates. It is possible that these grey measures lie along synclinal axes of folding, since they closely resemble grey beds more widely exposed to the north, in the district examined in 1908, where they appear to underlie fossiliferous Silurian measures.

*Post-Ordovician, Austin Brook Quartz Porphyry.*—The Ordovician slates, sandstones, etc., occur for a number of miles along the shores of Nipisiguit river, south of the southern boundary of the granite batholith. About half a mile below the Great falls of the Nipisiguit, at a point some 7 miles south of the boundary of the area of the main map-sheet, the sediments are followed by quartz-porphyry and associated rocks, that extend along the river for over a mile to the mouth of Austin brook and for an unknown distance beyond. The area of quartz porphyry is important, since within it occurs the iron deposits.

Normally, the quartz porphyry is a dark rock full of transparent, glassy grains of quartz often small in size, and usually accompanied by white crystals of feldspar lying in a dense matrix. At times the phenocrysts are large, and in some cases, those of feldspar are fully half an inch in length. Almost invariably, the rock has a schistose parting, and in certain zones or areas it has been changed to chloritic and sericitic schists.

The contact of the quartz porphyry and the sedimentary series was seen at one locality, where it appeared conformable to the bedding planes of the clastics. The quartz porphyry appeared to be intrusive, and, possibly, the intrusion took the form of an immense sill. The porphyry seems to have been involved in the main folding of the region, and in age, therefore, is probably pre-Devonian.

*Post-Ordovician, Basic Dikes.*—North of Tetagauche river, and to a less extent to the south, are exposures of dark, basic rocks called diabase in the field. They

[1] H. M. Ami, Summary Report for 1904, Geol. Surv., Canada, pp. 289-290.

apparently belong to a series of dikes some of which appear to be of considerable magnitude. Somewhat similar forms cut the Austin Brook quartz porphyry, but were nowhere observed cutting the Nipisiguit granite.

*Devonian, Nipisiguit Granite.*—Exposures of granite occur on the lower reaches of Little and Middle rivers and on Nipisiguit river from above Rough Waters to a point about 5 miles above Pabineau falls, or over a distance, in all, of about 8 miles. Though scarcely a single exposure of granite was found in the areas between the waterways, it is fairly evident that all the observed exposures belong to the western part of a single batholith whose major axis runs north and south with a length of about 11 miles. The eastern part of the granite body is covered by the younger, overlying Carboniferous sediments lying east of the Nipisiguit.

Typically, the granite is a grey, biotite granite, with a slightly pinkish tinge, due to the presence of numerous, large crystals of feldspar. The larger feldspars lie in a fine, grey matrix of feldspar, quartz, and abundant biotite. Other varieties of granite are less abundantly present. Pink aplite dikes are common.

The granite undoubtedly penetrates the Ordovician slates and associated sediments, sending dikes into them and altering them in the neighbourhood of the contact. Along the course of the Nipisiguit, numerous exposures show the granite passing under the red, Carboniferous beds of the Bathurst formation, of which the lowest beds—for a few inches or more—are usually of the nature of a fine arkose, composed of material derived from the breaking down, apparently *in situ*, of the granite. At a number of points the contour of the plane of contact between granite and sediment is visible, and where this is so the old rotted surface of the granite may be seen to have rounded, mammillary outlines, while the rock itself presents parting planes concentric with the outline of its surface.

The Bathurst granite appears to have been intruded at a period intermediate between the folding that, farther north, involved Silurian measures, and the deposition of the beds of the Bonaventure formation of late Devonian or early Carboniferous age. Therefore, the granite is regarded as being of Devonian age.

*Devonian, Bonaventure Formation.*—Within the area covered in 1909, only one exposure of the Bonaventure formation was seen. In the previous year, the formation was met with at intervals along the sea coast. The beds are usually dark red in colour, flecked with white from carbonate: they consist of coarse conglomerates, coarse and fine sandstones, shales, and less often, dolomitic beds.

These beds, as exposed along the shores of Nipisiguit bay and westward along Chaleur bay, have been correlated by a number of observers with the Bonaventure beds as exposed on the island of that name lying off the extremity of Gaspé peninsula, Quebec. The Bonaventure formation has usually been classed with the early Carboniferous, but in recent years doubt has been expressed as to the propriety of so doing, and the opinion advanced that they should rather be regarded as of Devonian age.[1] In the previous Summary Report of 1908, the Bonaventure beds were assigned to the Carboniferous, on the supposition previously expressed, or implied by various geologists, that these beds conformably underlaid the Millstone Grit east of Nipisiguit river. This year's examination of the area, however, failed to confirm the supposed equivalency of the beds underlying the Millstone Grit and those of the Bonaventure formation lying along the coast, and, therefore, following Clarke, they are now considered to be late Devonian rather than early Carboniferous.

*Carboniferous, Bathurst Formation.*—The beds of the Bathurst formation are red coloured, fine conglomerates, sandstones, and shales, and are exposed at intervals along the banks of Nipisiguit river almost from its mouth to a point several miles above Pabineau falls. Sandstones and shales are the common varieties; conglomerates are comparatively rare. The measures lie almost horizontally, with only a very slight

[1] Clarke, J. M., New York State Museum, Memoir 9, pp. 92-96, 1908.

eastward dip. Cross bedding is common. The formation overlies the Nipisiguit granite, and a number of contacts are exposed on the Nipisiguit. Nowhere was a true basal conglomerate seen, the basal bed usually being an arkose several inches, to a foot or so, thick. The curious mammillary outlines of the planes of contact between granite and sediment, as well as the regular concentric parting planes in the plutonic rock, have already been mentioned.

The absence of basal conglomerates, the presence of an arkose apparently derived from the granite directly below, the mammillary outline of the contact plane and the concentric partings in the granite, so like exfoliation planes, all suggest an æolian origin for at least a part of the Bathurst formation. The presence of fine shales and the occasional beds of conglomerate seem to negative this supposition. As the district in question seems to lie about on the last shore-line of the advancing sea of Carboniferous time, possibly æolian and aqueous deposits may have irregularly alternated with one another prior to the more permanent submergence during the time of the formation of the Millstone Grit, beds of which outcrop not far to the east, and apparently conformably succeed the Bathurst beds.

*Quaternary.*—Stratified gravels, sands, and clays, accompanied by distinct terraces, occur along the lower slopes up to heights of 250 feet to 300 feet. Boulder clay occurs, and in one section was observed to hold interstratified, cross-bedded layers of sand. Over considerable areas the country is completely mantled with boulders, often of large size. Certain hills are apparently composed of tumultuous aggregates of boulders of all sizes that seemingly have been glacially transported. Imperfectly preserved glacial striæ were observed at a few points within the area examined in 1908, but none were recorded during 1909. The transported material, so widely distributed over the whole country, is of rocks such as underlie the district or are believed to occur farther inland. The imperfect evidence collected apparently indicates that, at least in the last recorded stages of glacial times, the movement of the ice sheet was northward and outward from the interior of the Province.

## ECONOMIC GEOLOGY.

The main interest of the district, as far as economic geology is concerned, centres about the iron ore deposits of the Nipisiguit river. Within the area examined this year, manganese deposits also occur, on Tetagauche river near the falls above the last road bridge. The Nipisiguit granite has been quarried to a small extent, the stone having been used for bridge piers on the Intercolonial railway, also for certain buildings in Bathurst, etc.

### Iron.

The Nipisiguit iron deposits are found on both sides of Austin brook where it empties into Nipisiguit river at a point about 16 miles south-southwest of Bathurst. The deposits are the property of the Canada Iron Corporation. This Company is, at present, completing a railway running from the site of the ore bodies, along the west side of the Nipisiguit to a point of junction with the Intercolonial railway, not far from where this railway crosses the river. When completed, the new line will have a length of about 16 miles.

Up to the end of September—with the exception of the sinking of eight diamond drill holes, and a very slight amount of stripping—little development work had been done in connexion with the ore bodies, the energy of the Company being chiefly directed toward the completion of the branch railway.

Austin brook, where it joins the Nipisiguit, flows about south-southeast, in a narrow valley with steep sides rising 60 feet to 80 feet above the floor. East of the brook, the country is comparatively level; west of the stream, the land rises in a

broken ridge bounded on the west by a depression somewhat analogous in size and course to that occupied by Austin brook. One ore body lies west of Austin brook, running in a southerly direction between that stream and the Nipisiguit; the remaining ore bodies, in two groups, lie east of Austin brook.

Nearly the whole of the surrounding country is heavily wooded, rock exposures are comparatively rare, and, altogether, there are only ten exposures or groups of exposures showing ore. The conditions, therefore, are very unfavourable to the study of the nature and forms of the deposits. The following statements are, in a measure, provisional only, pending a more detailed study of the evidence collected.

The ore bodies lie within the area of the Austin Brook quartz porphyry already described, and near a considerable body or a number of dikes of the so-called diabase. They have sharply defined walls, are largely of magnetite, and apparently have the forms of steeply-dipping, flattened lenses, the major axes of the outcrops trending nearly north and south. The character of the ore is indicated by the following figures derived from the results of nearly 70 analyses of samples taken at intervals of 10 feet from the cores of four diamond drill holes. The logs of the drill holes and accompanying analyses were very kindly placed at the disposal of the writer by Mr. Fulton, the local manager of the mining company:—

| | | |
|---|---|---|
| Iron, average, between.. .. .. .. .. | 47·0% and 51·0%; | range, 39·6% to 58·7% |
| Sulphur, average, between.. .. .. .. | 0·17% and 0·27%; | range, 0·009% to 2·433% |
| Phosphorus, average, between. .. .. | 0·77% and 0·89%; | range, 0·385% to 1·222% |

The ore consists largely of magnetite, with sometimes a considerable proportion of hematite. Fine quartz, and probably various silicates occur through it, giving the ore a finely-banded appearance. Quartz in small and large, often crenulated veins, is common; the mineral also forms comparatively large lenticular-like aggregates. Pyrite is somewhat abundant along narrow zones, and in some instances is very abundant in the foot-wall. At times the nearly pure sulphide forms lenticular aggregates nearly a foot in diameter. Within the ore body were observed narrow, discontinuous bands of nearly pure, fine silicates, perhaps representing altered country rock. In common with the country rock, the ore exhibits a prominent parting, or schistosity, striking about north and south or parallel to the direction of the main axis of outcrop. In the ore itself, this is accompanied by an apparent banding simulating bedding; the zones of quartz veins, of sulphide, and of intermixed or interbanded gangue, all follow the same direction, and all, at least roughly, dip parallel with the walls of the body.

Because of the lack of a sufficient number of natural or artificial exposures, any estimate of the size and general attitude of the ore bodies must largely depend on the evidence furnished by the diamond drill holes, and on the magnetometric survey by E. Lindeman of the Mines Branch. The outcrops are too few and too scattered to yield definite results.

According to the plan of the magnetometric survey, confirmed by the distribution of the natural exposures, the ore bodies lie in three main groups, the longer axes of which, at the surface, run, roughly speaking, north and south.

The body lying west of Austin brook, and known as No. 1 deposit, is, at its northern end, exposed over its full width. At this point the outcrop had a width of about 150 feet, with sharply defined walls dipping westerly at an angle of about 45°, giving a true thickness to the body of about 105 feet. A vertical drill hole sunk in the hanging-wall near this point, entered ore at a depth of about 40 feet and indicated a true thickness of about 90 feet. A second vertical drill hole bored at a point about 700 feet farther south, intersected ore at a depth of 50 feet, and yielded a calculated thickness of nearly 80 feet. A third drill hole, started at a place about 500 feet west of the last, and inclined toward the east at an angle of 20°, cut ore at an equivalent vertical depth of 410 feet—where the ore body appeared to be about 65 feet thick. The results of the magnetometric survey indicate that, the ore body extends at least 1,000

feet farther south, or, over a distance in all, of about 2,000 feet. As far as present knowledge goes, the walls apparently preserve a nearly uniform southerly strike and westerly dip, the angle of dip, in the northern half, being about 45°.

A second body or group of ore bodies, known as No. 2, lies east of Austin brook, the southern end commencing on the valley slope at a point about 1,000 feet east of the apparent end of No. 1. The course of the axis of the second body diverges about 23° from that of the first. At the southern end a group of outcrops has a maximum width of a little over 40 feet, with nearly vertical walls. The southern extremity is well exposed, and the body is seen to end in a number of irregular fingers projecting into schistose country rock. Northward, ore outcrops at a few points for a distance of about 1,200 feet, and the indications are that the body remains at about a constant width, forming a comparatively narrow band. The magnetometric survey points to a horizon of practically the same length, but containing two ore bodies following one another along the strike.

A third ore body or group of ore bodies known as No. 3, lies east of Austin brook, and about in line with the prolongation of the axis of No. 1: commencing at a point about 1,800 feet north of it. Four diamond drill holes have been placed in this body, but the results of one only are at present available. The log of this drill hole, together with the position of surrounding exposures, indicates a body of ore about 100 feet thick, dipping west at an angle of about 75°. In this instance, the drill passed through ore from a point about 20 feet below the surface to one 350 feet beneath it. Exposures of ore occur at the surface over a length of only 300 feet, but the magnetometric survey of E. Lindeman, supplemented by one carried out by Mr. Fulton of the Canada Iron Corporation, indicates an ore-bearing horizon of much greater length: perhaps totalling in the neighbourhood of two-thirds of a mile. It is possible that over this distance the ore may occur in more than one distinct body, and the magnetometric surveys also seem to indicate the existence—along a parallel line a few hundred feet west—of other bodies.

Besides the above main bodies, an outcrop of iron ore was seen in one of the cuttings on the line of the new railway not far above the falls on the Nipisiguit. The presence of other bodies of ore in the district is to be expected, but their discovery is practically possible only by making use of magnetometric methods.

All the information available seems to indicate that, the deposits have the form of beds varying in width from a maximum of 105 feet to a minimum of about 40 feet. In all cases the walls are sharply defined, and dip westerly at angles ranging from 45° to nearly 90°. The three groups of ore bodies do not seem to represent one original zone separated into three by faults, since, in the case of No. 2 body, what appears to be an original, natural end, is exposed.

The country rock of the three deposits is believed to be, in the main, quartz porphyry, or as is more commonly the case, a schistose derivative. In that rock the planes of schistosity in country rock and ore are, on the whole, parallel to one another, and to the bounding planes of the ore bodies and lines of banding in the ore. The ore bodies seem to have suffered from the forces producing the schistosity of the country rock, and, at the same time, to have been guided in assuming their positions by the greater degree of schistosity of the country rock along certain zones. The visible end of No. 2 body seems to indicate that the ore penetrates the country rock—not that the country rock was later than, and penetrated the ore.

The invariable presence of a rather high amount of phosphorus in the analyses indicates a considerable amount of apatite, a mineral whose presence in bulk usually indicates a direct or indirect igneous origin, and not a sedimentary origin nor one analogous to that of the more common types of veins. The very general presence of quartz veins in the ore and their absence or comparative uncommonness elsewhere, strengthens the above deduction, and weakens the argument for a sedimentary origin of these bodies, which their bedded-like forms at first view suggests.

The present conclusion is, that the ore bodies are of pegmatitic types, and that their formation has been due to the action of forces accompanying or following igneous invasion or invasions the results of which are not otherwise apparent; they do not seem to have been directly associated in origin with the quartz porphyry. If this view of the origin of the ore bodies is the correct one, it seems highly probable that their true shapes are those of very flattened lenses; that the depths to which the individual lenses extend will prove to be, on the whole, not much greater than their maximum extension at the surface; and that the lenses will, as they approach their limits, thin out and end—as far as mining is concerned—rather rapidly.

(In the above considerations, the presence of the pyrite has been only briefly touched upon, since study has not sufficiently far advanced to determine, with any degree of certainty, the relative age of this mineral.)

## Manganese.

A quartz vein carrying manganite, cuts red slates on the south bank of the Tetagauche above the last road bridge, and only a short distance below the falls on the river. The deposit was worked a number of years ago, but the tunnel leading in on the vein is now caved in, thus preventing any detailed examination. At its outcrop on the steep river bank, the vein is seen, in places, to be at least 13 feet wide, to be nearly vertical, and to be accompanied by roughly parallel, narrow veins. The quartz is coarse, and white in colour; it forms most of the vein, the manganite occurring in narrow seams and small patches or aggregates of plates, or in semi-detached, imperfect crystals or fine grains. The vein is irregular in outline, holds inclusions of country rock, and is much fractured. From information gained from nearby residents, it is believed that during mining operations solid or nearly solid ore was found to occur in pockets. Manganite, in small quantities, also occurs in the dump of several shallow trenches sunk a short distance back from the river, at a point several hundred yards farther down stream.

# SUMMARY REPORT OF THE WORK OF THE LATE MR. HUGH FLETCHER IN NORTHERN CUMBERLAND COUNTY, NOVA SCOTIA. COMPILED FROM HIS JOURNAL BY R. W. ELLS.

Mr. Fletcher left Ottawa for Nova Scotia on June 16, to continue the study of the geology of the northern portion of Cumberland county, including the large areas underlain by Permian or upper Carboniferous strata extending northward to the shore of Northumberland strait.

The more important portion of this work was, apparently, the separation of the areas underlain by lower Carboniferous shales and gypsum from those occupied by the Millstone Grit and Productive Coal Measures; and the determination, as far as possible, of the horizons of the small coal seams which occur along the northern border of the coal basin, between the Joggins shore and the Styles coal mine, north of Springhill Junction. The mapping of the Permian strata was also considered specially important. All these formations have been closely studied in former years in the areas to the east and south. In this work he was assisted by Malcolm McLeod, and John D. Mackenzie, both of whom had been his assistants in former years.

The detailed mapping of the district proceeded satisfactorily until the middle of September, when, on the 15th of the month, on a trip from Springhill to the Joggins coal mines, Mr. Fletcher contracted a cold through getting wet in a rain storm, and was seized with a chill which speedily developed into a severe attack of pneumonia. In spite of the best medical skill and nursing procurable he died, after a week's illness, at the residence of Mr. Baird, in the village of Lower Cove, Cumberland county.

From Mr. Fletcher's notes—taken from his journal—it would appear that a large portion of the season was spent in examining in detail the somewhat faulted area extending from the vicinity of Chase Lake brook and Black river—both branches of Philip river—westward to the shores of Cumberland basin near the head of the Bay of Fundy. In this strip of country lying north of the main Springhill coal basin, are a number of collieries, including the Styles mine on the east, north of Springhill Junction, and the Joggins colliery on the west, on the shore of Cumberland basin. Some of these have been worked more or less successfully for a number of years, and the tracing out of the horizons of the several seams on which they are located, engaged much of Mr. Fletcher's time.

The relations of the several divisions of the Carboniferous are somewhat complicated throughout this area, owing to the presence of faults and overlaps. While no definite results of the careful surveys carried on throughout the season by himself and his assistants are yet available, the field notes show that explorations were conducted throughout the entire area north of the Springhill and Joggins coal basins to the shore of Cumberland basin, where the lower portion of the celebrated Joggins section of the Carboniferous rocks begins. It is believed that the work of the past season, ended so abruptly as it was, will, when put in order, do much to solve the peculiar geological structure of this district.

In connexion with the work in this district, a visit was made in June by Mr. Fletcher, with Mr. R. W. Ells, to the district in the neighbourhood of Dorchester, New Brunswick. This visit was made for the purpose of determining more precisely the limits of the lower Carboniferous, Millstone Grit, and Permo-Carboniferous or Permian formations which extend across the interprovincial boundary into Nova Scotia, where Mr. Fletcher's work was being carried on.

From June 21 to July 1, Mr. Fletcher spent much time in consultation with the managers connected with the coal mines of the Springhill basin and those nearer the Joggins shore. Subsequently, some time was devoted to a closer study of several of the smaller coal seams which have been opened in this area.

After some days spent with his assistants in northern Cumberland, Mr. Fletcher went to Cape Breton on July 20, and in company with Mr. R. Smith, and Mr. W. Campbell, examined certain copper deposits near Campbell pond. Of this area he remarks that, in the bed of a small brook there is a vein of white quartz about 20 inches wide, holding a little shattered rock—a reddish, greenish, and grey felsite, with epidote, chlorite, and other minerals—which has been worked to a small extent. Branches from the main vein extend into the wall rock, some of which show copper staining, while a little hematite occurs along planes of shattering. About seven years ago, Messrs. James McDonald, Judge Finlayson, and others, sank a shaft to a depth of 65 feet on this vein, in the bed of the brook. The vein at the shaft runs about north and south, but away from the shaft breaks up or swings more to the southeast. At the bottom of the shaft (at present worked about 14 feet above the original 65 ft. bottom) the dip of the vein is flatter than at the surface, where it is nearly vertical. Cuts have been made in various directions at the 51 ft. level, but do not show much copper. At some places near the surface, however, the quartz is well mineralized with pyrite, copper glance, etc.; but a very large proportion of the vein matter taken out is quite barren. A good showing is seen in a trench on the surface. The vein, considering the formation in which it occurs, is persistent, although in places it breaks up into stringers. The shaft is dry, the brook carrying no water in the dry season. The ore is apparently not present in sufficient quantities for profitable extraction.

Some days also were spent in an examination of the Richmond coal field, with Mr. Mellinger and others interested in the structure of that coal basin.

Returning from Cape Breton, a study was made by Mr. Fletcher and his assistants of the somewhat complicated structure near the Leicester road, east of the Styles mine. Along the road the relations of the lower Carboniferous, the Millstone Grit, and the Permian are somewhat intricate. Indications of faults, in the form of slicken-sides and broken strata, are numerous, and while characteristic Permian beds are exposed at a number of places, certain of the higher beds are possibly Triassic.

Of the Permian, he remarks that the outcrops seen on the road to Shinemecas include, in addition to the usual red beds of that formation, conglomerates and reddish and whitish sandstones similar to those which occur with the upper Permian in the Joggins section. Some of these Permian rocks are slickensided, polished, veined, and drused with quartz and hematite, and are so much altered that they resemble the conglomerates at Arichat, in Cape Breton, which have been mapped as Devonian.

In August, from the 10th to the 20th, an examination was made of the area between Springhill and Thompson station, and of the country adjacent to Philip river and in the vicinity of Roslin, Hansford, etc., where certain areas of gypsum show unconformity, due in part to faults and in part to overlaps.

On August 23, Mr. Fletcher went to New Brunswick, where he met R. W. Ells, and W. J. Wilson, of the Geological Survey, and Dr. Henderson of London, England, who was boring for oil and natural gas in certain areas in the counties of Albert and Westmorland. This excursion extended as far west as Norton between Sussex and Hampton, where the bituminous Albert shales and their relations to the Perry conglomerates at the base may be seen. Mr. Fletcher was much interested in this area, as it enabled him to make a comparison between these New Brunswick rocks and those which in Nova Scotia he had for some years closely studied about Minas basin and in the county of Antigonish and elsewhere.

On September 3, Mr. Fletcher, accompanied by Mr. Tennant of Amherst, went to Williamsdale, about 8 miles south of Oxford Junction, in Cumberland county, to

examine the 'Arsenic mine,' reported as occurring at that place. His notes state that the deposit of ore—which is said to be gold bearing—occurs on a small brook about 2 miles east of Collingwood corner. In the bed of this brook, about half a mile from the main road, there is a belt of laminated rock with veins of quartz up to a foot in width, the belt having a maximum thickness of 6 feet. The direction of the largest veins and of the 6 ft. belt is apparently about N 10° E, and the angle of dip about 60° (varying from 30° to 90°). Some surface work on the outcroppings in the bed of the brook had been done for a distance of 70 feet, 30 feet of which contain great quantities of arsenical pyrites in ragged lenses or bunches. The ore is reported to contain $7 in gold to the ton, and a little silver. No work has been done below the brook level; but, if possible, a slope will be driven down following the richest bunch of ore. The veins appear to occur in the ordinary greenish and dark diabase and felsite of the neighbourhood. Dark Silurian slates containing graptolites occur a short distance up stream. The deposit thus resembles in its mode of occurrence, that at Peleg brook, where similar veins were first exploited for gold. The deposit is interesting, and may be of value. Several tons of ore have been mined and shipped.

Prior to his final illness, the last few days of Mr. Fletcher's work were spent in renewed attempts to solve the complicated problem of structure connected with the coal outcrops found along the northern margin of the Springhill basin, as far east as the Styles mine.

# TUNGSTEN DEPOSIT OF MOOSE RIVER, NOVA SCOTIA.

*(E. R. Faribault.)*

## INTRODUCTION.

On December 15, 1909, the writer left Ottawa for Nova Scotia, under instructions to make an examination of the tungsten-bearing deposit of scheelite, discovered in the spring of 1908, near Moose River Gold Mines, in Halifax county. The work was undertaken for the purpose of studying the character and structure of the deposit, and to help, if possible, in planning development work.

This deposit had been examined by the writer in October, 1908, when a survey was made of the then known scheelite veins, and in the Summary Report for that year, some notes were published on the discovery, character, and probable structure of the deposit.[1]

On Moose River sheet, No. 50, published by the Geological Survey in 1893, the location and the anticlinal structure of the veins are indicated, although not until ten years afterwards were these veins known to carry the tungsten-bearing mineral scheelite. The same year, a special plan of the Moose River gold mines, situated 2 miles east, was published, with some notes giving details of the structure of the gold-bearing veins, which closely resembles, in many respects, that of the tungsten veins.[2]

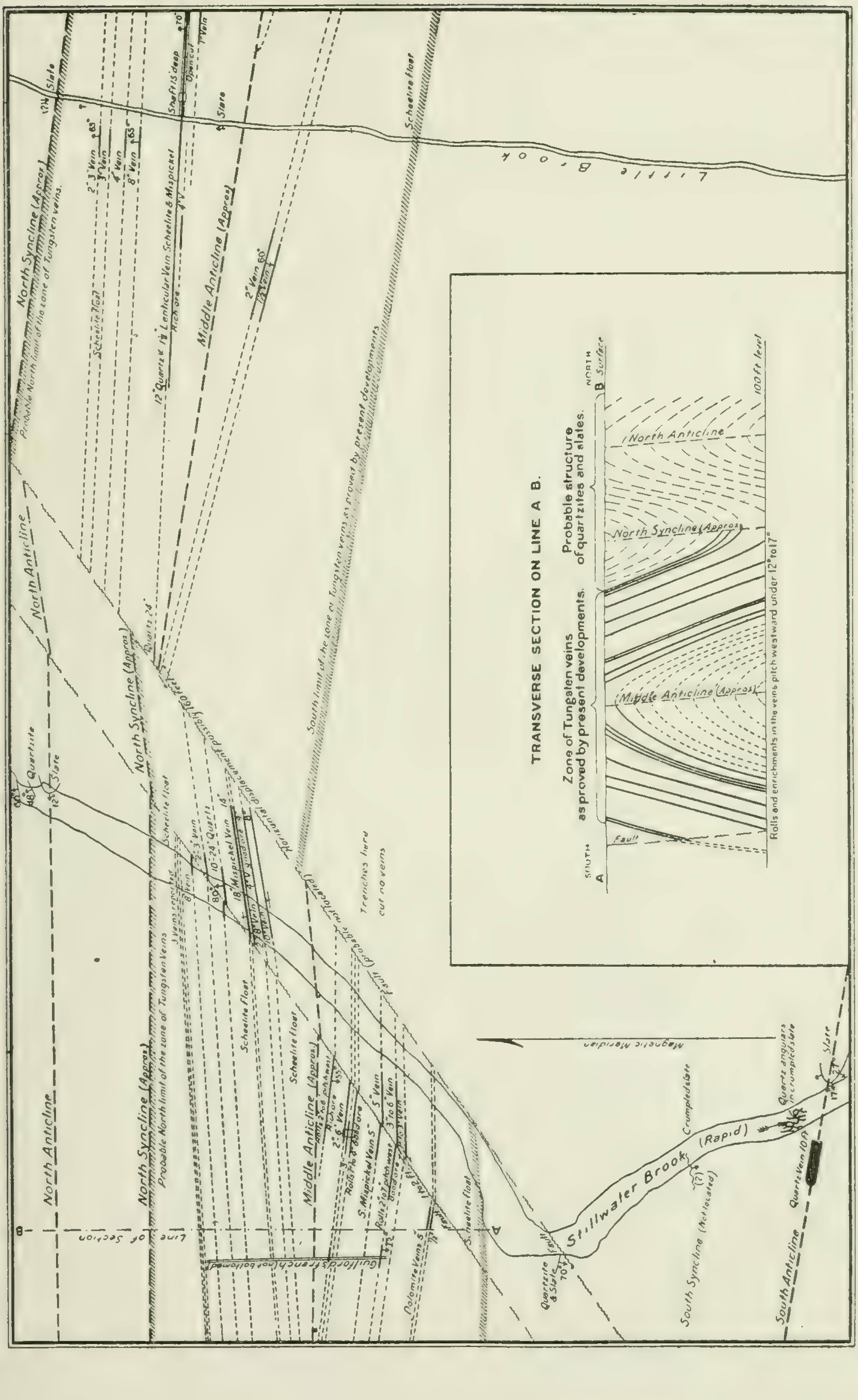
At the last visit, it was only possible, in the two days at my disposal—with the assistance of the original discoverers and prospectors, Reynolds, and Currie—to make a compass and chain survey, and a hasty examination of the area prospected. From these surveys and those previously made, two plans were compiled: one, on a scale of 250 feet to 1 inch, giving the general topographical features of the district and the distribution of the tungsten veins; the other, 60 feet to 1 inch, accompanied by a section, showing the structure of the veins discovered and their probable extension at the surface and in depth. A reproduction of the latter plan and section, on a reduced scale, is published herewith.

The tungsten deposit is situated in Halifax county, 28 miles northeast of Halifax city, 12 miles directly north of Ship harbour on the Atlantic coast, and 2 miles west of Moose River Gold mines. It is located on Stillwater brook, a branch of Fish river flowing south through Ship Harbour Grand lake to the Atlantic. Moose River Gold Mines is the post-office name of a mining centre surrounded by woodland. It is reached by a good mail-coach road, running southeast for 34 miles from Shubenacadie, a station on the Intercolonial railway, 40 miles by rail from Halifax. Thus, the distance by coach and rail is 74 miles from Moose River to Halifax. When the Eastern railway, projected between Halifax and Canso, is constructed, the tungsten deposit will be less than 8 miles from a railway.

## GENERAL GEOLOGY.

The rocks of this district consist of beds of altered, grey quartzose-sandstone or quartzite, generally called 'whin,' interstratified with beds of dark grey slate. They are the lowest known strata of the Goldbearing series in the Province, and occur along the apex of the highest and most prominent anticlinal fold which passes through the Moose River gold district. Thus, the lower or Goldenville division of the Gold-

[1] Summary Report, Geological Survey, for 1908, pp. 155-158.
[2] Summary Report, Geological Survey, Vol. X, pp. 113-114 A.




PLAN AND SECTION SHOWING PROBABLE STRUCTURE OF INTERBEDDED TUNGSTEN VEINS

MOOSE RIVER, HALIFAX COUNTY, N.S.

By E. R. Faribault

Scale 120 feet to 1 inch

bearing series attains, here, its maximum thickness, estimated at 16,000 feet, which, added to the 11,700 feet of slate of the Halifax division, as exposed on Black river, in Kings county, gives a total thickness of 27,700 feet for the whole series.

The country is drift covered, and rock exposures are very scarce; but taking advantage of the rock exposures offered by the prospecting done last summer, together with the natural sections of rocks exposed along Stillwater brook, it has been possible to work out the geological structure with a fair degree of certainty and accuracy. The conclusions reached confirm those advanced in last year's report.

The accompanying plan and section show that, on the apex of the major anticline, and within a space of 620 feet in width, the strata have been folded into three minor anticlines and two synclines, the axes of which have a general east and west course and pitch westward at low angles, varying between 12° and 17°.

A small fault has been located, cutting a 10 to 24 inch quartz vein, exposed in the bed of the brook, and also two veins, uncovered on the west side of the brook. the fault the strike of the strata is deflected towards the north, and on the north limb displacement of 1 to 2 feet in a southwesterly direction. On the southeastern side of the fault of the strike of the strata is deflected toward the north, and on the north limb of the anticline the beds dip at higher angles than in the corresponding positions on the west side of the fault. This dislocation, the general structure of the strata, and the fact that search made on the eastern side of the brook for the continuation of certain veins uncovered on the western side has proved unsuccessful, indicate that there is, probably, a second and more important fault, situated about 50 feet southeast of the one just described. The location and magnitude of this second, inferred fault have not been accurately determined. It is estimated, however, that the block of strata on the southeastern side of the fault has been displaced, horizontally, for about 160 feet to the northeast; but, as yet, there is nothing to show the extent of the verical displacement nor the angle of dip.

The north anticline is well defined in the west fault-block on the left bank of Stillwater brook, 40 feet below the bridge, where a bed of slate, exposed at low water, was observed to curve and pitch westward at an angle of 12°; but the axis has not been located in the east block.

The north syncline was not exposed in the west block, and its location in the east block, along the little brook, is doubtful.

The position of the middle anticline is fairly well established in the east and west blocks by the evidence furnished during surface development made last summer, which places this line farther north than it was thought to be when last year's report was written. This anticline is the most important from an economic point of view; for all the tungsten veins so far discovered are situated on one side or the other of this axis.

The south syncline could not be located in either of the blocks.

The south anticline is well exposed in the east block, in the bed of the brook, where, at low water, a bed of slate may be observed to curve around on the arch of the fold and to pitch west at an angle of 17°; also, on the western shore, where a vein of coarse, white quartz, 10 feet thick, apparently forms a prominent saddle, pitching westward on the arch of the fold. Immediately north of this anticline and for a short distance up the brook, the strata are much crumpled and fractured, and are cut by irregular masses and stringers of quartz, indicating the possibility of small undulations occurring in this vicinity, and, possibly, for some distance down the brook, where the rocks are concealed.

The Moose River anticline, traced westward, at a distance of 36 miles, passes through the Waverley gold district, one mile to the north of which were discovered, last year, a few interbedded scheelite-quartz veins, similar to those of Moose River. Toward the east, it divides into two major anticlines, the southern one passing through Beaver Dam gold district at a distance of 12 miles from Moose River, and

the northern one through Fifteenmile Stream gold district, 24 miles distant. The Moose River anticline has been accurately located on the map-sheets Nos. 41, 49, 50, 54, 55, and 67 published by the Geological Survey.

No igneous rocks have been found in the immediate neighbourhood of these deposits, the nearest intrusion being a large mass of granite, 7 miles to the southeast. It is possible, however, that granite underlies this area of sedimentary strata at no great depth, for at several places the slates have been altered into a knotted phyllite, and the quartzite into a quartz-schist.

## ECONOMIC GEOLOGY.

The history of the discovery, and the general character and composition of the tungsten-bearing veins were described in last year's Summary Report. The development work done last summer by Messrs. Reynolds and Currie has resulted in the discovery of several veins, and has furnished much valuable data bearing on the general distribution and geological structure of the deposit.

All the scheelite-bearing veins so far discovered, may be classed as interbedded veins; for they coincide with the bedding planes, and occur in thin layers of slate, interstratified with beds of quartzite. The veins are distributed in equal numbers on the north and the south limbs of the middle anticline, forming a well-defined system of saddle veins, similar in structure to those of the gold deposits of the Province. The section drawn across the anticlinal fold on the west side of Stillwater brook shows nine veins uncovered on the south limb and about as many on the north, all situated within a space of 150 feet wide.

The veins on the north limb are, from their interbedded character, necessarily parallel to one another, and the same is true of those on the south limb; but as the axis of the anticline pitches westward, the two sets of veins converge toward the west until they meet on the anticline, where they underlie one another in the form of saddle-veins.

The width of the veins varies from a fraction of an inch to 24 inches, but few of them, and this is especially true of those showing the most scheelite, average more than 4 inches. They are generally quite uniform in width, though some of them show the enlargements and rolls, so common in the gold-bearing veins. These rolls plunge westward at low angles, which correspond with the pitch of the anticline, also approximately with the line of intersection of the cleavage and bedding planes, and may indicate, as in the case of the gold veins, the general pitch of the ore shoots.

The vein matter consists essentially of quartz, scheelite, and mispickel in varying proportion. The quartz is mostly translucent, white, and glassy, and quite different from that of the gold-bearing veins of the Province.

The scheelite is honey-yellow to pale reddish-brown in colour, is coarsely crystalline, and shows distinct cleavage. It often constitutes a large part of the smaller veins; in some of which it occurs in series of lenses or rolls. In the larger veins the scheelite is mainly confined to the outer parts, where it occurs in thin, irregular patches.

The mispickel is always massive, and varies very much in quantity in the different veins. In one or two of the veins it is the predominant constituent; but, generally, it is less abundant than the scheelite, and sometimes is scarcely visible. It also occurs abundantly in the slate adjoining the veins, in very minute, well-formed crystals, commonly surrounded by a narrow zone of white mica, with the scales at right angles to the surface of the mispickel.

White, crystalline dolomite has been observed in a few veins. Scattered through the veins are patches of fine, white, scaly mica, with a silky lustre; and embedded in the scheelite and quartz are slender needles of black tourmaline. At the outcrops and along the selvage of the veins, the scheelite is sometimes slightly decomposed into a

bright canary-yellow powder, which is tungsten acid, or tungstite; but no wolframite nor hübnerite has been observed. Galena, pyrite, and pyrrhotite, which are commonly found in the gold veins, have not been observed. Several assays of the ore for gold, made by Mr. A. L. McCallum, have given negative results in every case.

It is evident that the tungsten veins differ materially in composition from the gold veins of the district. The character of the veins, their constituents, the presence in them of mica and tourmaline, and the metamorphism of the country rock adjoining the veins, all tend to prove that the tungsten deposits are the results of deep-seated emanations, along a zone of fractures following the axial plane of the great Moose River anticline, at the close of the period of granite intrusion.

## General Development.

All the prospecting has been confined, so far, to a comparatively small area, extending 700 feet east and west along the course of the veins and 200 feet across them. This work was all done by the two Reynolds brothers and Currie, and consists mostly of trenching across the strike of the rocks to prove the ground. Some of the veins discovered were traced along their courses for short distances by prospect pits and shallow open-cuts; and on one of them a pit was sunk to a depth of 15 feet. Considering the amount of work done and the limited area covered, the results obtained are very satisfactory.

Several tons of ore have been produced as a result of the prospecting already done. We are informed that one or two tons have been forwarded to Halifax and elsewhere, for the purpose of experimenting on a practical process of concentration, as well as to determine the best method of producing tungsten acid from concentrates and at the same time eliminating sulphur and arsenic. Although scheelite is richer in tungsten than the other ores of tungsten, wolframite, and hübnerite, it was for a time considered less desirable, owing to the difficulty of its metallurgical treatment; but the modern method of reduction, in the electrical furnace, has rendered it fully as desirable.

The zone of tungsten veins is probably limited on the north by the north syncline, situated at a distance of about 100 feet north of the middle anticline, and it probably extends some distance farther south than the present developments. Otherwise, the extent of the mineralized zone is not known; but enough veins have been exposed to show the importance of the deposit from an economic point of view. That the area is much larger than might be supposed from the veins exposed by Reynolds and Currie, is shown by the fact that, scheelite has been found in drift on the continuation of the same anticline, 900 feet west from Stillwater brook, and in an isolated boulder a mile and a quarter west. Further exploration will no doubt also disclose scheelite veins outside of the known zone, especially toward the south. Scheelite float has also been found 1,350 feet south, on the east side of Stillwater brook, where the first discovery was made. This material may have drifted south from the main deposit, or from another group of veins, possibly situated on another minor anticline not yet located.

Since the discovery of these deposits, scheelite was found 2 miles east, on the same anticline, at the Moose River gold mines, where, on the Touquoy property, at the depth of 200 feet in Kaulbach's vertical shaft on the Dowell lead, pieces of scheelite as large as a hen's egg, in quartz, were brought to the surface at different times; also on the Moose River Gold Mining Company's property, where, at a depth of 90 feet in the Cameron shaft, a pocket was found containing a few pounds of ore.

As already mentioned, scheelite was discovered last fall by Mr. A. L. McCallum, at a place one mile north of the Waverley gold mines, which are situated on the same anticline, 36 miles west of Moose River. Two or three interbedded quartz veins bearing scheelite, similar to those of the Moose River deposit, have been uncovered here, and a quantity, possibly two tons, of ore has been produced.

Scheelite has, therefore, been found at different places over a stretch of 3 miles along the Moose River anticline, and at another place 36 miles west, on the western continuation of the same great upheaval: indicating, seemingly, the persistence of this system of anticlinal veins, and its possibilities as a good field for further exploration.

Mr. F. H. Mason, chemist, formerly of Halifax, states that he has often found traces of scheelite in his analyses of the tailings from the Lake Lode mine at Caribou, situated 6 miles north of Moose River on the next main anticline. Professor T. L. Walker reports that concentrates collected at Caribou mines were found, on chemical examination, to contain 0·22 per cent of tungstic acid; and that a sample collected in June, 1908, at the Moose River mill, contained 0·52 per cent tungstic acid.

Scheelite, of a light, smoky colour, was found in a quartz vein intersecting the Middle Rabbit lead, on the Ballou gold mine, Malaga, Queens county. It is very probable that scheelite occurs in many other gold districts in Nova Scotia, especially in those situated near granite masses, and a systematic search for it over the old dumps and old workings may be rewarded by other important finds.

## CONCLUSIONS.

From this preliminary study of the Moose River tungsten deposit, the following conclusions have been reached:—

The development work already accomplished has proved beyond a doubt that the deposit has a real, economic importance.

The structure and distribution of the tungsten veins are so intimately bound up with the rock structure that a consideration of the structure of the anticlinal fold and faults is necessary to its perfect understanding.

The general structure has been fairly well worked out at the surface; but much yet remains to be proved and determined with more accuracy and detail, both at the surface and in depth, before an attempt can be made to lay out a definite plan of operation that would give the best results.

It is very important to prove the existence, as well as the location and magnitude, of the fault, which has been described above as probably occurring on the east side of Stillwater brook; for such a fault would divide the mineralized belt into two distinct sections, each requiring to be independently developed, and, perhaps, also exploited.

It will no doubt be found desirable to develop the belt of mineralized veins by means of two shafts, one on each side of Stillwater brook, to a depth of about 100 feet; then to cross-cut north and south across the whole belt, and drive a series of drifts on the courses of the most promising veins intersected. The two shafts may be sunk vertically on the apex of the anticline, or on the dip of one of the best veins, situated nearest to the anticline, so as to keep in the centre of the zone of mineralization. To locate these shafts, it will be necessary to determine more accurately the position of the anticline on both the east and west sides of the brook.

There will probably be found, as in the gold veins, a series of well-defined ore-shoots of no great width, but of considerable length, pitching westward, approximately parallel with the plunge of the apex of the anticline, at an angle of about 12° to 17°. In the gold veins the ore-shoots generally vary from 40 to 200 feet in width; and several of them have been mined for lengths of over 1,500 feet along the pitch. But, owing to the low angle of the pitch, an ore-shoot may have a length, at the surface, of several hundred feet along the strike of the vein; while a shaft sunk on the dip of the vein may reach the bottom of the ore-shoot at a depth of much less than 100 feet; on the other hand, an ore-shoot, if followed westward along its pitch, may be found to extend much over 1,000 feet in length. To keep the development work in the zone of ore-shoots, it

may be found advantageous, for deep mining, to sink an incline shaft on the apex of one of the most promising veins, and to develop the overlying veins by means of cross tunnels and drifts at different levels.

A few hundred feet north of the deposit on Stillwater brook, a small amount of water-power is now available, which may be increased and developed to advantage, for utilization in mining development.

On Fish river—2 miles to the south of the deposit—there is a much larger available source of water-power which could be developed, and from it electric energy transmitted to the mine.

The mine is surrounded by woodland, which affords a good supply of both hard and soft wood, suitable for mine timber, as well as for fuel.

## SOUTHERN PART OF LUNENBURG COUNTY, NOVA SCOTIA.

*(E. Rodolphe Faribault.)*

### INTRODUCTION.

During the past season, the writer was occupied in completing the geological and topographical mapping of the southern part of Lunenburg county, along the Atlantic coast southwesterly from Mahone bay to Vogler cove, and extending inland to Bridgewater. This completes the surveys and other field work necessary to finish the Mahone Bay sheet, No. 88, and the Lunenburg sheet, No. 89.

The assistants in the field were Messrs. J. McG. Cruickshank, and M. Y. Williams.

For the purpose, particularly, of indicating the lines which prospecting should follow in the district, as well as to facilitate the work of operating mines, attention was given, in an especial degree, to the structural geology; since it has been established that the gold-bearing veins occur, almost exclusively, along anticlinal folds. The development in the rocks of a strong, slaty cleavage, obscuring the bedding planes, and the widespread drift cover, concealing the surface, made the accurate location of the various anticlines and synclines both difficult and tedious.

### CHARACTER OF DISTRICT.

The district surveyed is for the most part covered by low, undulating hills of glacial drift, seldom over 300 or 400 feet high, having a general north and south trend and forming prominent headlands along the sea coast. The intervals between the hills are generally occupied by swampy land and chains of small lakes; or by rocky barrens affording good rock exposures; or they are strewn with granite boulders and debris from the north.

Lahave river crosses the area in a southeasterly direction, and occupies a marked depression: which is continued as an inlet of the sea, less than a mile wide, for 12 miles to Bridgewater, affording good navigation for large and small vessels. Petite Rivière, a stream of less importance, runs into the sea 6 miles farther west, and has several water-falls along its course that are partly utilized for small mills.

Lunenburg and Bridgewater, the two chief towns of Lunenburg county, are situated in the area examined. Lunenburg, the most important fishing station in the Province, has an excellent harbour, and has a large trade with the West Indies. Bridgewater is a progressing railway and lumbering centre at the head of navigation on Lahave river. Settlements of fishermen are scattered along the sea-shore of the mainland and islands: especially on many small, rocky coves and inlets which afford good shelter for boats.

In the vicinity of the coast there is little land suitable for agriculture. Small farms and gardens are successfully cultivated by the use of an abundant supply of fish refuse and seaweeds as fertilizers. Inland, between Bridgewater and Mahone Bay, there are good farms and several fine orchards.

### GEOLOGY.

With the exception of a few small patches of lower Carboniferous limestone and gypsum on Second peninsula, and some of the adjoining islands, the whole area is occupied by the series. No rock exposure could be found on Second peninsula, because of a heavy covering of glacial drift; but numerous angular blocks of shell

limestone and grey compact limestone were observed at several places along the north shore, from the Government wharf to Bluff head, also on the north and south side of Mason island lying between the two peninsulas. These deposits indicate the position of the outer edge of the lower Carboniferous basin of Mahone bay and St. Margaret bay referred to in the Summary Report for 1907, page 79.

Several specimens of invertebrate fossils, obtained in 1907 and 1908 from various localities in the Mahone Bay basin, were examined by Mr. Lambe, who reports that they consist of one species of coral and two species of brachiopods: all characteristic of the lower Carboniferous limestone. The respective species, together with the lcalities from which they were obtained, and Mr. Lawrence M. Lambe's descriptions, are as follows:—

(1) *Lithostrotion Cæspitosum*, Martin.—Specimens from Sheep island, Goat island, and the south end of Stephen island, in Mahone bay. These specimens are of interest, as the species has not hitherto been recorded from this side of the Atlantic. *L. cæspitosum* was originally described from the Carboniferous limestone of England.

(2) *Dielasma Sacculus*, Martin.—Half a dozezn specimens, from Mahone bay, belong to this species, which was primarily described under the name of *Terebratula sacculus*, also from the lower Carboniferous of England, and was later recorded as occurring in rocks of the same general horizon by Sir J. William Dawson (see Acadian Geology) at a number of localities in Nova Scotia.

(3) *Productus Cora*, D'Orbigny.—Specimens of a large Productus from Goat island, Sheep island, south end of Stephen island, Seaboyer's on south side of Deep cove, and north shore of Second peninsula. The species represented appears to be an unusually large form of *P. cora*, d'Orbigny, which is found abundantly, but of smaller size, in the Carboniferous limestone of Nova Scotia, and is widely distributed in the Carboniferous of Europe as well as America.

## Goldbearing Series.

Practically the whole of the district examined, with the exception of the small areas of lower Carboniferous limestone and gypsum on Second peninsula, is underlain by the quartzites and slates of the Goldbearing series. In the absence of fossils or other conclusive evidence, this great series of rocks has been referred to the lower Cambrian, though, possibly, it may be Pre-Cambrian.

The whole series falls naturally into two distinct lithological divisions: a lower one, called the Goldenville quartzite; and an upper one, called the Halifax slate.

The Goldenville division is mostly composed of thick-bedded, bluish and greenish grey quartzite, locally called 'whin,' interstratified with numerous beds of slates of different varieties and colours, and from a fraction of a foot to several feet in thickness. This division constitutes the productive gold-bearing rocks of the Province.

The Halifax division is made up of argillaceous slates, generally of a dark grey colour, in many places graphitic and pyritous, and varying to greenish-grey or light grey in colour. Some beds are quite arenaceous, with occasional thin layers of flinty, quartzose rock, generally heavily charged with iron pyrites.

The rocks of the Goldbearing series in the region examined have been forced into a succession of parallel folds, running northeasterly and southwesterly.

The greatest width of the area of the Goldbearing series in the district examined, measured at right angles to the folding, is 16 miles. A transverse section along a line from Bridgewater to West Ironbound island gives eight major anticlines and seven synclines, with a few minor folds. The courses of the axes of folding were all located and traced across the area surveyed.

The following list of anticlines and synclines, gives the order in which they occur along Lahave river from West Ironbound island to Bridgewater, together with the gold mines situated along the anticlines:—

Moser Island anticline.
1. Spectacle Island syncline.

Dublin Shore anticline. The Ovens gold mines.
2. South Parks Cove syncline.

Park Creek anticline.
3. North Parks Cove syncline.

Pentz Section anticline. Indian Path mine and Somerset gold discovery.
4. Middle Lahave syncline.

Wentzel Lake anticline.
5. Pleasantville syncline.

Juniper Brook anticline.
6. Upper Lahave syncline.

Conquerall Bank anticline. Dares Lake gold discovery.
7. Dayspring syncline.

Bridgewater anticline. Leipsigate and Blockhouse gold mines.

As already stated, the greater part of the area is occupied by the Halifax slate division. The Goldenville quartzite is brought up to the surface only in the southwestern part of the Lunenburg sheet, where the Dublin Shore anticline and the Pentz Section anticline have a pronounced pitch to the eastward, forming two prominent, broad domes of quartzite extending southwesterly beyond the limits of the area examined.

The southern dome of quartzite begins on the sea-shore half a mile east of West Dublin post-office, spreads out in a broad circle and extends southwesterly on both limbs of the Dublin Shore anticline, including Green bay with the inner part of Cape Lahave island on the south, and the mouth of Petite Rivière and the head of Broad cove on the north.

The northern dome of quartzite begins 3 miles to the northwest of the southern one, on the eastern side of Petite Rivière, 1 mile east of Crouse Town post-office, where it circles around Brown lake on the eastern pitch of the Pentz Section anticline; the south limb extends southwesterly toward Vogler cove, and the north limb westerly toward County Line station on the Halifax and Southwestern railway.

On these two domes the interstratified slates, at certain horizons, are in much greater volume than the quartzites, especially near the top of the division, where they attain a great thickness. The line of demarcation between the two divisions is thus not nearly so well defined in this district as it is in the eastern part of the Province, the passage from quartzites to slates being more gradual.

## Igneous Rocks.

The only igneous rocks observed were four dioritic dikes on the Ovens peninsula. The dikes are well exposed on both the east and west side of the peninsula, at a distance of a quarter of a mile south of the Ovens gold mines, and immediately south of the old mill of the Acadia Gold Reduction Company, still standing on the eastern shore of the point. All four occur within a distance of 250 feet; they vary in width from 3 to 9 feet, and are generally conformable in strike and dip with the stratification of the slates, though in many cases, they distinctly cut across them. The only other instance of a basic eruptive occurring in the Goldbearing rocks along the coast is at Tangier, where a dike cuts across the sediments at right angles to their strike. In the Gaspereau valley and its vicinity many similar dikes have also been observed intruding both the Goldbearing series and the Silurian.

### Glaciation.

The entire area must have been covered with moving ice at the time of the glacial period. The general course of the ice, as indicated by striæ, was toward the south and southeast, conforming to the directions of the valleys of Lahave, Petite Rivière, and other main streams, and to the general trend of the hills. Glacial drift, largely made up of till, with granitic boulders, and of debris transported from South mountain, covers most of the hills. Debris of amygdaloidal traps and other characteristic basic eruptives from North mountain on the Bay of Fundy coast, was also observed at many places, showing that at some period, at least, the ice field moved across the whole Province.

## ECONOMIC GEOLOGY.

### Gold.

The slates of the Halifax division of the Goldbearing rocks are generally considered by the miners to be much less likely to bear auriferous veins than the quartzites and slates of the Goldenville division, because, so far, no important mine has been located on them anywhere within the Province; except at Caribou. Rich veins have been found in them, but these were generally small and irregular, and without the uniformity and extent of those occurring in slate belts lying between rigid walls of quartzite. It may be remarked, however, that in the eastern part of the Province, on account of the deep glacial erosion, the slates of the upper division seldom occur along the anticlines, and much less often on the domes which are the only favourable places for the formation of gold-bearing veins.

In the region under study, every one of the eight anticlines occurs in the slate of the Halifax division, and only two of them have brought the quartzites to the surface, namely, the Dublin Shore and the Pentz Section, where these rocks occur at the southwestern end of the anticline. The Dublin Shore anticline passes through the 'Ovens' gold district, and the Pentz Section anticline passes through the Indian Path gold district and the Somerset gold discovery. Special detailed surveys have been made of the gold mining districts of the Ovens and Indian Path, but a report on the structure of these districts must be deferred until all the surveys are plotted and compiled.

*Somerset Gold Discovery.*—On May 20, 1905, rich 'float' gold quartz was discovered by Nathaniel Slaughenwhite of Italy Cross, at Somerset, on the west side of Petite Rivière, one mile south of A. Slaughenwhite's house, at the south end of Beach hill. The quartz is dark, ribboned, and striated, indicating that it came from an interbedded vein having a thickness of about 10 inches. During the following two summers a surface pit was sunk 63 feet north of the first discovery through 26 feet of drift to the bed-rock, and a tunnel was driven north for 57 feet, on the bed-rock. No float of the rich ribboned quartz was found in this exploratory work. This may have been due to the fact that the discovery is situated on the eastern pitch of a broad anticlinal dome of quartzite and slate, where the veins, conforming to the stratification, have a general north and south direction. East-west, or at right angles to the probable direction of the vein, should, therefore, be the more promising direction for exploratory tunnelling.

The same rule should be applied in prospecting at the Augustus Reinhardt discovery of rich gold float, similarly situated on the same anticlinal dome, about one mile west of the Slaughenwhite discovery.

### Iron Ore.

Some of the dark, rusty-weathering slates of the Halifax division are heavily charged with iron pyrites, generally occurring in small cubes distributed through the rock, or in massive form along the bedding planes. From the decomposition of these

slates have originated deposits of bog iron ore found in various low, swampy places, along rivers, and about lakes. Several such deposits were observed, notably along both banks of Lahave river, and on the hill extending to the north of Kingsbury to Rose point. It is doubtful if any of these deposits are of sufficient extent and depth to be of commercial value, but they might be worth investigating, as they are nearly all situated within easy reach of good shipping points.

### Limestone and Gypsum.

The presence of limestone on Second peninsula appears to have been generally overlooked by the present inhabitants, though it was certainly known to the earlier French settlers, who had a limekiln on Limestone hill, opposite the Government wharf, and one on Goreham point, once thickly settled by the French.

Gypsum was not observed anywhere, but several large funnel-shaped 'sink-holes' were located on the Second peninsula, on the farms of John Young, George Acker, and Freeman Berringer, testifying to the occurrence of deposits under the heavy drift covering. As these deposits of limestone and gypsum are quite close to the Government wharf, where good shipping facilities are available, they may prove of commercial value.

### Clay.

Extensive deposits of alluvial clay occur at many places along the low, swampy intervales, and glacial clay, largely made up of granite debris, is abundant on many hills. Samples of some of the more promising clays were collected for examination as to their value for brick making.

A brick-yard was in operation about 65 years ago near Lunenburg, at the Saltpit wharf on the south shore of Back harbour. It is reported that bricks were also made by the early French settlers on Brick hill, situated on Goreham point on Second peninsula.

## ARCHÆOLOGY.

Indian implements, including arrow-heads and spear-heads, flint, and pieces of earthenware, have been found on Backman beach on the north side of Second peninsula, and at other places along this part of the coast. Specimens of these are on exhibition in a small museum in the town hall at Bridgewater, and in the archæological collection of the provincial museum at Halifax.

# THE CLAY AND SHALE DEPOSITS OF NOVA SCOTIA, AND PORTIONS OF NEW BRUNSWICK AND PRINCE EDWARD ISLAND.

*(Heinrich Ries.)*

The investigation of the shale and clay deposits in the above-mentioned region occupied the summer of 1909. The writer was assisted in the work by Mr. Joseph Keele. The object of the study was to ascertain, as far as possible, what geological formations were clay and shale-bearing, and which of these deposits were adapted to the manufacture of clay products.

With this end in view, the clay and shale deposits were examined as thoroughly as was possible, in the time at our disposal; and samples were collected for testing in the laboratory. The last was an important part of the work; since one can tell but little from the appearance of the material in the field.

The different brick plants in operation were also visited, and samples of their product taken for crushing, transverse, absorption, and freezing tests.

## NOVA SCOTIA.

The geologic formations of Nova Scotia range from the Pre-Cambrian to the Triassic, and they are overlain nearly everywhere by a mantle of pleistocene material of variable thickness.

In certain formations the character of the material is such that, there is little probability of its being of any value to the clay-working industry, and these are considered first.

### Formations of No Probable Value to the Clay-worker.

*Pre-Cambrian.*—This consists of crystalline rocks of either igneous or metamorphic character, which underlie a large portion of southwestern and southern Nova Scotia proper, and a large part of northern Cape Breton, as well as scattered areas in southeastern Cape Breton. None of the Pre-Cambrian rocks are of plastic character, nor do they become plastic when finely ground. They have no doubt been weathered to residual clays in the past; but these have probably been removed by glacial action. Only one deposit of residual material came to our attention, and this was a pocket on Coxheath mountain, near Sydney, the clay there having evidently been formed by the decomposition of a light coloured felsite, which occurs in some abundance in that region. The clay deposit is too small to be of any economic value. In recent years several attempts have been made to utilize this rock in the manufacture of firebrick, but up to the present time they have not been successful. Unfortunately some persons have promulgated the idea that, the felsite could be used by itself for brick manufacture; but this is impossible, since the material is lacking in plasticity, and could not be utilized unless some bonding material was mixed with it. If a good fireclay could be found in the neighbouring Sydney coal field, it might serve as a binder for the felsite.

It is possible that veins of feldspar or quartz, of sufficient purity and thickness to be workable, might be found in the Pre-Cambrian area, but diligent inquiry failed to discover any.

*Silurian.*—The rocks of this system underlie a narrow area on the south side of the Annapolis valley, and irregular areas in the eastern half of Pictou and northern half of Antigonish counties. They are economically important because of the deposits

of iron ore which they contain. Associated with these are somewhat extensive beds of shale, but most of them are rather slaty in their character, and of exceedingly doubtful value for the manufacture of clay products. On weathering they might produce plastic clays, but even so, the majority of them would be rather ferruginous. A few samples were collected for testing, in order to definitely determine their value.

*Devonian.*—The Devonian rocks underlie a narrow belt of irregular width extending through the central part of the Province, and underlying some small areas in southwestern Cape Breton, to the northeast and southwest of St. Peter bay, as well as on the northeastern side of the Straits of Canso, near Hastings.

These rocks were examined at a number of localities, and were found to be either too schistose in their character, or where of argillaceous nature contained too much silica, present either as disseminated sand in the shale, or interbedded sandstone layers. Were it not for the sandstone layers, the material, though siliceous, could no doubt in some cases be used for brick manufacture.

*Permian.*—This underlies a discontinuous area extending from Chignecto bay eastward along the north shore to a little beyond Merigomish harbour. No shales of any value were found in it.

*Triassic.*—The Triassic rocks form one belt following the Annapolis valley, and another one along the north shore of Cobequid bay, tapering out east of Truro. They are usually sandy in their character, and not to be looked upon as a source of either clay or shale.

## Important Clay-bearing Formations.

From what has been said above, it will be seen that the formations likely to yield clay or shale deposits of value must be the lower Carboniferous, Millstone Grit, Coal Measures, and Pleistocene. These are few in number, but nevertheless they underlie areas of considerable size.

*Lower Carboniferous.*—Underlying, as they do, a rather extensive area in central Nova Scotia, and another one in Cape Breton, it is to be regretted that the lower Carboniferous rocks have not been more widely looked into by clay-product manufacturers. The formation is, however, somewhat variable in its character, carrying, as it does, beds of shale, conglomerate, gypsum, and limestone. Those shales closely associated with the gypsum beds may be of value for common brick manufacture, although they frequently contain considerable quantities of impurities, such as gypsum nodules, concretions of iron carbonate, or sandy streaks. At some points though, as near Pugwash, the shale occurs in large beds, and works up well to a plastic mass: the more so as it is slightly weathered. At that locality it supports one of the most active and best equipped brick plants in the Province.

Northeast of Shubenacadie, also, promising shales were found in the lower Carboniferous, while in the so-called limestone series around Sydney there were found a number of beds which appear promising for brick manufacture, provided the sandstone layers do not occur too thickly.

*Millstone Grit.*—This is well exposed in the area north of the Coal Measures in the Joggins district; north of the Pictou Coal Measures; south and southeast of Hawkesbury; and west and southwest of the Sydney coal field.

One cannot predict the universal distribution of promising clay or shale beds in the Millstone Grit, but small beds are not uncommon. Unfortunately, outcrops are scarce in many of the areas underlain by the rocks of this age, which increased the difficulty of finding clays or shales in it. Several deposits of fair importance were seen, and may be referred to in passing. In the Sydney region, a pit has been opened near the Steel works, exposing a bed of soft bluish shale, not less than 5 feet in thickness. A second deposit occurs near the coke oven plant of the Dominion Iron and

Steel Company, and a third one outcrops along the east shore of Sydney harbour, near Victoria Mines post-office. Although the tests of these have not yet been completed, it is highly probable that they represent a grade of material considerably higher than brick clay.

In the Pictou coal region, a rather heavy bed of mottled, shaly clay has been found northeast of Woodbourne station, on the Intercolonial railway. Preliminary tests have shown its adaptibility to the manufacture of pressed brick. It may be said here, that there is some doubt as to whether this bed lies in the Millstone Grit or Permian conglomerate, but the former view seems the more reasonable.

The Millstone Grit contains at least one shale bed of some thickness in the Joggins area; but it is probably of red burning character.

*Coal Measures.*—These represent the most important clay and shale-bearing formations of Nova Scotia, and were carefully examined in the several areas in which they occur. The largest is the Sydney field, of Cape Breton, and extends from the Big Bras d'Or channel to Cow bay, with only one important interruption, at Cape Percy on the northeastern shore of Cow bay, where the Millstone Grit cuts out the Coal Measures.

Owing to the almost uninterrupted line of cliffs which fringe the shore-line, a fine series of exposures was obtained. The Sydney coal field is cut into several parts by somewhat deep northeast-southwest bays; which has rendered it difficult for geologists to correlate the sections of the several subdivisions of the field. It can be said that the coal seams are interstratified with a series of shales and sandstones. These are bent into a number of gentle folds, forming the bottom of a broad trough which dips out under the sea. Throughout the field, therefore, low dips prevail. This gives the beds broad outcrops, but still the dip is sufficient to carry the bed rapidly under cover. Toward the northwestern and southeastern parts of the field the sandstone beds predominate, and the shales are of poorer quality, but in the central portion the shales are as abundant as the sandstones. The shales themselves range from smooth, fine-grained, plastic ones, of grey or red colour, to others which are quite siliceous in their character, and of doubtful value. One important deposit is found underlying a large portion of Cranberry head, near Sydney Mines. It is a smooth, greyish shale, and may prove of value for vitrified wares. In the final report it will probably be referred to as the Cranberry Head type, as it appears at a number of points. A second type found at a number of localities in the Nova Scotia Coal Measures is a somewhat soft, reddish shale, well exposed along the shore just west of Cranberry head. Not a few of the shale beds are rather siliceous in appearance and touch, and it would be unwise to express any definite opinion on them until the tests have been completed.

It seems curious that up to the present time these shales have been completely overlooked; and while it is true that they do not occur in deposits of great thickness, still they are easily accessible, and are capable of supplying a considerable quantity of raw material.

Numerous references to fireclays in the Sydney field have been published; but as far as we were able to ascertain, this region does not contain any high grade fireclays, although some of them may prove to be low grade. Unfortunately most coal miners have formed the habit of calling any 'under clay' a fireclay.

*Pictou Field.*—In this field there are numerous shale beds associated with the coal seams, but they are best developed in the central portion of the area, and the most important known up to the present time are higher up in the section than the coal beds. Many of these shales when ground and mixed with water are of strong plasticity, but they unfortunately contain such a high percentage of carbonaceous matter as to require great care in burning, and some of the shale beds are too high in carbonaceous or petroliferous matter to be used at all; while others have to be avoided

on account of the abundant siderite concretions; but in spite of these disadvantages, the field is an important holder of commercially valuable shale deposits. In some parts of the section, as along Coal creek, south of the Allan shaft at Stellarton, the beds of shale are occasionally quite free from carbonaceous material. In only one instance is an under clay worked, viz., at the Drummond colliery at Westville, where a hard shale is mined for the manufacture of bricks. The most important utilization of the shales is near New Glasgow, where they are made into common and pressed brick, flue linings, sewer pipe, and drain tile. Pleistocene drift clay is sometimes added to the pipe mixture.

*Inverness Field.*—This small field carries a number of shale beds associated with the coals, but few of them are of great thickness; indeed, none of them are equal in volume to those worked in the Pictou area. A good bed outcrops on the shore a few hundred feet south of the dock, and a plastic shale is said to underlie the 7 ft. coal. Most important, however, is the bed of grey, plastic clay which overlies the 13 ft. seam, and is found at several points where that seam is cut through by streams. It is, probably, a No. 2 fireclay, and varies in thickness from 18 inches to 3 feet. If the tests prove it to be of refractory character, it would be practicable to work it in connexion with the coal.

*Port Hood Field.*—Here, too, there are seattered shale occurrences in both the Millstone Grit and Coal Measures; but the most important is along the shore a short distance north of Judique harbour, where a bluish-grey shale, with a vertical dip, and about 8 to 10 feet thick, outcrops for some distance along the shore.

*Joggins Area.*—This field contains a number of thin shale seams interstratified with sandstone in the Coal Measure rocks, but few of them are of any thickness. The most important, perhaps, is south of McIntyre brook; while a second one, of possible value, underlies the coal seam at Joggins.

*Pleistocene Clays.*—These may be roughly divided into two classes: (1) glacial clays, usually of stony character, but very plastic, tough, and red burning; and (2) marine clays, often strongly laminated, but also quite plastic and red burning. These two types of clay are rarely used for anything but drain tile and common brick. A few pressed brick are made from them, and the smoother ones could be utilized for the manufacture of common ornamental terra-cotta and cheap art pottery. The marine clays are best developed in the Annapolis and Shubenacadie valleys, while the stony, glacial clays are worked mainly in the Cape Breton region.

A most remarkable clay, and one of undetermined age, is that found at Shubenacadie and in the Musquodoboit valley. The material is a highly plastic clay, of dark grey, white, or mottled red and white colour, lying beneath the glacial drift, and resting, possibly, on bed-rock. Its thickness, as indicated by a series of borings made by Mr. Keele, ranges from 7 to probably 50 feet. Scattered lumps of lignite were found in the clay at Shubenacadie, and it is hoped that the age of these can be determined.

It is exceedingly difficult to determine the exact area underlain by this deposit, owing to the heavy mantle of glacial drift covering the region; but the fact that the material is found at several points extending over a distance of 7 miles, indicates its probable extent, unless some of the masses have been pushed along with the drift. Borings could, of course, only be made at those points where the drift cover was thin or absent.

The clay burns to a cream colour, and fairly dense body at a comparatively low temperature. It is at least semi-refractory in its character, and may prove to be a stoneware clay. Some test bricks were made from a carload lot of this clay, taken from a shaft sunk in the deposit at Shubenacadie.

It is safe to say that nothing like it has been found elsewhere in Nova Scotia, and its resemblance to some of the Cretaceous fireclays of New Jersey is striking.

### NEW BRUNSWICK.

As most of our time was required for the examination of the Nova Scotia clays, but little of the field season was left for New Brunswick. Several localities were examined, and the following is a condensed statement of the results.

In the vicinity of Albert Mines, in Albert county, there are some very promising beds of Devonian shales, which are probably of red burning character. In the event of the oil-shales at that locality being developed, these shales will be of importance for brick manufacture, but aside from this, they may prove to be of value for making pressed brick to be shipped to other markets. Nearby there are also red burning shales of lower Carboniferous age. Some of the latter are located along the line of the railway.

Many shale deposits, some of which may prove to be of refractory character, are associated with the coal deposits around Minto and Chapman, northeast of Grand lake. Similar shales underlie and overlie the coal 12 miles southeast of Harcourt.

Marine clays are worked for common, and some pressed brick, at both St. John and Fredericton.

### PRINCE EDWARD ISLAND.

The only clay resources of Prince Edward Island are of Pleistocene age. Common brick clays are found at a number of points, but are worked to but a slight extent.

## CLAY WORKING INDUSTRY.

Up to the present time, the clay deposits of Nova Scotia have been but little developed. Common brick are made at Annapolis, Middleton, and Avonport in the Annapolis Valley region, and at Shubenacadie, and Elmsdale in the Shubenacadie valley. Other yards are in operation at Sylvester, New Glasgow, Pugwash, Eden Siding, and Mira River. In most cases these are operated to supply a rather local demand, although the Annapolis and Pugwash brick are sometimes shipped some distance by water. Common pottery is made from the smoother sections of the surface clays south of Elmsdale. Most of the common brick yards re-press a few brick. A hard brick, known in the trade as a firebrick, but not really such, is made from the Carboniferous shales at Westville. Sewer pipe, flue linings, and drain tile are made from the shales at New Glasgow; and some drain tile are manufactured in the Annapolis valley by the same firms that produce brick.

It will be seen, therefore, that there is considerable room for expansion. If such development occurs, the markets will be mainly outside of the Province; except for common brick. At present the buildings in that region are constructed mainly of wood; but as the supply of this becomes scarcer and more expensive, brick must be utilized as a substitute. For outside markets, the plants should be located as near to water as possible, to avoid rail shipment.

It is hoped thaat the studies of the samples now being carried on will demonstrate the value of the clay and shales for making pressed brick, vitrified brick, earthenware, and perhaps stoneware, sewer pipe, etc.

## CLAYS AND SHALES IN THE MARITIME PROVINCES.

*(Joseph Keele.)*

Having received instructions to assist Dr. Heinrich Ries in an examination of the clays and shales of the Maritime Provinces, I left Ottawa on June 15, and proceeded to that region. After reaching the field, a few days were spent in company with Messrs. Ells and Fletcher, familiarizing myself with the stratigraphy of certain of the rock formations in which beds of shales are most abundant. On June 25, I joined Dr. Ries at Halifax, and we went to the Sydney coal field; from which point we had decided to begin the season's work.

The work consisted of prospecting for clays and shales suitable for use in the various branches of the clay industry; and in visiting the localities where these materials are already known to occur.

About 100 samples were collected from different localities; and shipped to Ottawa, for examination, and subjection to the usual series of tests, with a view of determining their utility.

In order that the samples should represent the average value of each deposit, the following method of collecting was adopted. When a bed of shale or clay was found which appeared to be of economic importance, and had a scarped face, a trench, deep enough to reach below the weathered surface, was dug completely across the face, at right angles to the bedding. The fresh material thus exposed was then broken down, and about 60 pounds taken as a sample.

The thickness of the deposit; the ease with which it might be mined; and its situation with regard to fuel, manufacturing, and transportation, were also considered in estimating the economic value of an occurrence.

Small samples of a few pounds' weight were taken from beds or deposits of less importance, or in certain cases to supplement the large samples taken from important deposits.

A light boring apparatus, consisting of a set of 1¼ inch augurs, which could be attached to about 30 feet of jointed piping, was used for testing deposits of surface clays where no face was exposed. A core could be drawn with this instrument, giving a complete section deep enough to prove the value of a deposit.

The greater part of the season was spent in company with Dr. Ries on the areas referred to in his report; but several journeys were made by the writer alone to other areas where clays and shales were known to occur. The localities visited were: River Denys, Guysborough, Arisaig, and Parrsboro, in Nova Scotia; also Albert Mines, and the Grand Lake coal area in New Brunswick. The Grand Lake area appears to be the most important of these localities, since there, an abundance of plastic shales—which may prove useful in the manufacture of brick and tile—occur in the Coal Measures. In mining the coal in this district, it is necessary to remove about 3 feet in thickness of accompanying shale, and great heaps of this material lie weathering on the surface at the different mines.

The principal mining operations are carried on at the village of Minto: the terminus of the New Brunswick Central railway.

A mine opened this summer near the shore of Salmon bay—about 7 miles east of Minto—has a good bed of underclay, which could be easily worked in connexion with the coal. The construction of the new Transcontinental railway through this region has revealed a very promising bed of plastic shale, at least 5 feet thick, lying close to the surface, at Chipman station, about 15 miles east of Minto.

After the departure of Dr. Ries from the field, the writer was directed to make borings on some important clay deposits situated in the valley of the Musquodoboit river, and at Shubenacadie in the Province of Nova Scotia. About two weeks were spent at this work, and a great deal of information was obtained regarding the extent and character of these clays, which will be more fully described in the final report.

The clay in the Musquodoboit valley underlies glacial drift; but is exposed at several points along the river, and on some of the brooks which have cut down to it through the overlying drift. The deposit is extensive, and may be traced for a distance of 7 miles along the valley; its width is unknown.

The borings at Middle Musquodoboit afforded a section of, at least, 50 feet; clays, silts, and sands with fragments of lignite. The beds are irregular both in vertical and lateral directions, and the prevailing colour of the clay is a mottled red and grey; but there are several beds of both light and dark grey colour, without any admixture of red. It is said by some pottery manufacturers who have examined it, to be a good stoneware clay; but whatever value in the clay industries the tests now being made may indicate, it is not commercially available at the present time, as it is situated about 15 miles from the nearest railway.

The deposit at Shubenacadie is crossed by the main line of the Intercolonial railway, and has been worked to a limited extent in the manufacture of stoneware. The clay is mined at present from a shaft sunk about 50 feet east of the railway track, and about a quarter of a mile south of the railway station. About 20 feet of drift overlies the clay at this point, the workable bed being about 10 feet thick. A boring at the bottom of this shaft showed 16 feet of grey silty clay. This was as deep as could be penetrated.

The upper surface of this underlying clay is also undulating, and does not conform to the present land surface; for at a distance of 200 feet north of the shaft the clay is found at less than a foot below the surface; the intervening ground being level. On the west side of the railway the ground rises slightly, and opposite the shaft, the clay was found to be from 9 to 13 feet below the surface.

In an endeavour to trace the extent of the deposit, a number of borings were made around the village of Shubenacadie; but most of these did not reach the clay, owing to boulders in the drift covering. Borings for water show that the deposit underlies most of the ground occupied by the village; but the amount of overburden is at most points too great to permit of it being worked. The colour of the clay is almost uniformly lead-grey; but it bleaches to a light grey or dirty white on exposure to the atmosphere, and there is no red colour present. The beds show the same alternation of clays, sands, and silts as those in the Musquodoboit region; but there appears to be more lignite present in the Shubenacadie deposit.

These deposits are of great geological interest: for, as far as we are aware, there are no similar ones anywhere else in eastern Canada. Dr. Ries has suggested a possible correlation for them in his report.

## WATER AND BORINGS BRANCH.

*(Elfric D. Ingall.)*

The routine of collecting the geological data, rendered available through borings made throughout the country, has been prosecuted throughout the year. It is regretable, however, to have to report that the response on the part of operators has not been what it should have been.

Apart from the collection of this new material, progress has been made in assembling and compiling information relating to the subjects dealt with in the prosecution of the work, from a wide range of literature descriptive of the geological formations of Canada and related portions of the United States.

The intelligent prosecution of any boring, whether made in search of water, gas, oil, salt, coal, or any other substance exploitable by this means, calls for very varied information; not only as to local details of the geological column to be bored through, but as to the broader geological conditions of the region.

It is also of importance that information should be available as to the difficulties encountered during the progress of previous borings made in the district, and as to the indications then encountered of the presence or absence of useful mineral substances.

Account must be taken of the experience gained elsewhere in apparently similar formations and under like conditions, also of the probable causes operating in the origination and distribution of workable bodies of the minerals sought.

In order to aid the drillers in the planning of their ventures, it is necessary to compare and correlate the information so that it can be rendered available. This will involve the Branch in an undertaking which will consume much time apart from that necessarily absorbed in the routine of collecting fresh boring records and samples of drillings; recording, filing, and studying them, and the preparation of this material for publication. In view, then, of the small means at command compared to the necessary extent of the work, and of the manifest benefit to accrue to the drillers and others interested, a strong plea is again made for the hearty and prompt co-operation of all those engaged in this line of business.

A slight consideration of the subject will surely bring conviction of the great utility of a central office, which will record, compile, and interpret all boring records, and thus render available the general conclusions to be drawn from such a mass of data. It will be evident, also, that this can be done without publishing the records received from any operators who desire to keep their results confidential.

During the greater part of the year, J. A. Robert acted as assistant, helping very materially in the inauguration of the system for filing and recording the records and drillings received, and in the classification of data relating to borings, etc., scattered throughout the official literature, as well as in other ways.

## SECTION OF MINERALOGY.

*(Robt. A. A. Johnston.)*

The work in the mineralogical section has been of the same general character as that of last year. There has been a marked increase in the number of inquiries of a technical character regarding Canadian minerals. These, in the main, have been made personally, and no record was kept of them; the replies to them, however, have taken up a great deal of time. Over 600 specimens have been received, examined, and reported upon.

The Educational Collections have, as heretofore, received careful attention, in order to maintain the standard to which they have been brought. In the case of one or two varieties used in these collections, we have been disappointed in securing supplies. It is hoped, however, that this difficulty will be soon overcome, and that the omissions from collections sent out last year may be filled. There have been frequent inquiries for a collection suited to the needs of the Continuation Classes of the public schools, and other classes of the same general character. To meet these requirements, a new collection has been arranged, to be known as Grade 2: and consists of 32 of the more common minerals, and 12 of the more common rocks. For this collection a new case has been designed. A number of these have been distributed, and are meeting with a good deal of approval amongst teachers.

Very considerable additions have been made to the Museum collection, as will be seen from the accompanying lists. Much of the credit for these is due to the efforts of Mr. R. L. Broadbent, who, in February last, was entrusted with the duty of making a collection of minerals from British Columbia and Yukon, for the Alaska-Yukon-Pacific Exposition at Seattle, Washington, U.S.A. These specimens are now the property of the Museum, and are being stored, pending the completion of the Victoria Memorial Museum building. Mr. Broadbent's report will be found appended hereto. The list of specimens collected by him in this connexion is given separately; for the reason that it seemed desirable to make a more easily available record of it than could otherwise be made. Previous to his departure for British Columbia in February, he was engaged in the general work of recording and labelling specimens for the Museum.

Some important additions have also been made to the collection of foreign minerals, mainly through the medium of exchanges. This collection is becoming increasingly useful in directing the efforts of prospectors and others in their search for economic minerals.

Mr. A. T. McKinnon has continued to render faithful and efficient service in collecting and preparing material for the Educational Collections. The packing and shipping of these collections has also been superintended by him. Between June 5, and October 5, he was engaged in collecting materials at various localities in the Provinces of Ontario, Quebec, New Brunswick, and Nova Scotia, during which time he secured over 14 tons of selected material for use in the collections.

Acknowledgments are due to the following gentlemen for much kindly advice in respect of localities, and in many instances for free contributions of material: Mr. M. J. O'Brien, Renfrew, Ont.; Mr. J. J. Fowler, Ottawa, Ont.; Mr. Bush Winning, Ottawa, Ont.; Dr. F. D. Adams, Montreal, Que.; Mr. John Cherry, Perth, Ont.; Mr. Wilson Bailey, and Capt. Wallbridge, Madoc, Ont.; Mr. Andrew Hamilton, Lascelles, Que.; Mr. S. J. McMeekin, Ottawa, Ont.; Mr. Chas. J. O'Connor, Long Point, Ont.; Mr. Wm. Stephens, Tennycape, N.S.; Mr. John Higson, Stellarton, N.S.; Mr. M. B. Spears, Pusey, Ont.; Mr. Ezra Churchill, Walton, N.S.; Mr. C. Noble Crowe, Lake George, N.B.; Mr. Harry Piers, Halifax, N.S.

Collections were distributed during the year, as follows:—

| Provinces. | Standard Collections. | |
|---|---|---|
| | Grade 1. | Grade 2. |
| Alberta | 4 | |
| British Columbia | 2 | |
| Manitoba | 5 | |
| New Brunswick | 6 | 4 |
| Nova Scotia | 8 | |
| Ontario | 53 | 6 |
| Quebec | 43 | 1 |
| Saskatchewan | 5 | |
| | 126 | 11 |

To foreign institutions.... 2

Special collections totalled 1,152 specimens.

Mineral chips, in sets of about 45 different kinds, were distributed, as follows:—

| Province. | |
|---|---|
| New Brunswick | 2 |
| Quebec | 1 |

**The following additions have been made to the Museum collection.**

DONATIONS.

Mr. A. L. Ogilvie, Ottawa, Ont.:—

Silver ore, from the Lucky Godfrey mine, township of Willet, Nipissing district, Ontario.

T. L. Willson, Ottawa, Ont.:—

A series of electro-metallurgical products.

Mr. John J. Caley, North Bay, Ont.:—

Calc sinter, from Trout lake, 20 miles north of Nemego station, Algoma district, Ontario.

Capt. Gilchrist, Ottawa, Ont.:—

Asbestos, Bell Asbestos mine, Thetford, Que.

Mrs. Angeline Lafrance, Montcerf, Que.:—

Infusorial earth, Montcerf, Ottawa county, Que.

Mr. Thos. Morrison, Bancroft, Ont.:—

Two slabs of marble from Bancroft Marble quarries, Dungannon township, Hastings county, Ont.

Mr. Wm. Mulligan, Sand Point, Ont.:—

Green diopside, Fitzroy township, Carleton county, Ont.

Mr. J. B. Black, Windsor, N.S.:—
Mountain leather, West Colchester, N.S.; partially inspissated bitumen, East Hants, N.S.

Rev. J. A. Mauseau, St. Felix de Kingsey, Que.:—
Broken crystals of white translucent quartz, from lot 8, range III, Kingsey township, Drummond county, Que.

Mr. W. C. Hamilton, the Leitch Collieries, Passburg, Alta.:—
Inspissated bitumen in calcite, from section 6, township 7, range 2, west of the 5th meridian.

Mr. R. H. Stewart, Moyie, B.C., per R. L. Broadbent:—
Pyromorphite, from the Society Girl claim, Moyie, East Kootenay, B.C.

Mr. F. Soues, Clinton, B.C.:—
Native arsenic with a little realgar in crystalline dolomite, from Watson Bar creek, Fraser river, B.C.; mispickel in quartz, Watson Bar creek, Fraser river, B.C.

Lake Copper Mining Company, New Glasgow, N.S., per R. W. Ells:—
Copper ore (chalcopyrite and pyrite with ankerite), from the Polson Lake mine, Antigonish county, N.S.

Mr. A. Gracey, Nelson, B.C., per R. L. Broadbent:—
Scheelite and tungstite in quartz, Kootenay Belle mine, Nelson Mining division, B.C.

Mr. Ivan A. Bayley, Sydney Mines, C.B., N.S.:—
Mountain leather, from Lower Five Islands, Colchester county, N.S.

Mr. R. L. Clarke, per J. A. Dresser:—
Pyrite and chalcopyrite, from Weedon, Wolfe county, Que.

Hon. H. R. Emmerson, per H. M. Ami:—
Sixteen samples of crude petroleum, from wells at St. Joseph, Westmorland county, N.B.; thirteen samples of crude petroleum, from wells at Dover, Westmorland county, N.B.

Mr. Thos. Watt, Pozerville, Alta.:—
Thenardite, Pozerville, Alta.

Carborundum Company, Niagara Falls, N.Y.:—
Crystallized silicon.

Mr. Bush Winning, Ottawa, Ont.:—
Hematite in thin films assuming the crystal outline of the enclosing muscovite, Villeneuve mica mine, lot 31, range I., Villeneuve township, Labelle county, Que.

Mr. C. J. Lutes, Tisdale, Sask.:—
Calcareous tufa, Tisdale, Sask.

Mr. Thos. Burgess, Ottawa, Ont.:—
Tennantite in dolomite, Breen's farm, near Bulger post-office, Renfrew county, Ont.

Mr. W. T. Mason, Montreal, Que., per H. M. Ami:—

Gold ore, from the Dr. Reddick claim, Larder lake.

Mr. Louis O. Hedlund, Hedley, B.C.:—

Specularite in quartz, Hixon creek, Cariboo district, B.C.

COLLECTED BY OFFICERS OF THE DEPARTMENT OF MINES.

Mr. R. W. Brock:—

Gold ore, from Poorman mine, Nelson, B.C.; native copper, from south end of Atlin lake, B.C.; copper ore, from the Stewart group of claims, Portland canal, B.C.; copper ore, from the Bear River camp, Portland canal, B.C.; copper ore, from the Swede group of claims, Lockeport, Queen Charlotte islands, B.C.; copper ore from the Klondike river, some miles above Hunker creek, Yukon.

Mr. A. M. Campbell, Ottawa:—

Specimen of scheelite in quartz from Waverley, Halifax county, N.S.

Mr. D. B. Dowling:—

Coal, from the 4 ft. seam on the Kneehill Coal Company's property, Carbon, Alta.; coal, from the Russel claim at the head of McLeod river, Alta.; lignite, from the Potter mine, southwest of Banff on the north bank of Battle river, Alta.; five samples of coal, from the Brazeau river, Alta.; coal, from the Pacific Pass Coal Company's property, Little Pembina river, Alta.; coal, from the Saskatchewan and Alberta collieries, Grassy lake, Alta.

Mr. E. R. Faribault:—

Scheelite, from the Reynolds and McCallum veins, Moose river, Halifax county, N.S.

Mr. B. F. Haanel:—

Massive ilmenite with implanted crystals of the same mineral, from the township of Ham, Wolfe county, Que.

Dr. Eugene Haanel:—

Iron ore concentrates and briquettes, from the Coehill mine, Hastings county; Calabogie, Renfrew county; Timagami, Nipissing district; and Moose mountain, Algoma district, in the Province of Ontario.

Mr. Joseph Keele:—

Clay, Mira brickyard, Cape Breton county, N.S.; shale, coast near Barachois harbour, south of Low point, Cape Breton county, N.S.; shale, between coal seams on coast near Low point, Cape Breton county, N.S.; fireclay (so-called), Fraser's quarry, Coxheath, Cape Breton county, N.S.; shale, Coal Measures, Brooks brickyard, New Glasgow, Pictou county, N.S.; shale, New Glasgow, Pictou county, N.S.; fireclay, Drummond colliery, Westville, Pictou county, N.S.; clay, Smalls brook, near Woodlawn station, Pictou county, N.S.; clay, Miller's brickyard, Eden Siding, Cape Breton county, N.S.; clay (with baddeckite), Baddeck, Victoria county, N.S.; fireclay, dark band in, Shubenacadie, Hants county, N.S.; clay, Shubenacadie, Hants county, N.S.; clay, Miller's brickyard, Shubenacadie, Hants county, N.S.; clay, Musquodoboit river at Middle Musquodoboit, Halifax county, N.S.; clay, Murphy brook, Middle Mus-

quodoboit, Halifax county, N.S.; clay, Diogenes brook, Denys river, Inverness county, N.S.; clay, West river, Antigonish county, N.S.; clay, from above coal seam, McLellan brook, Inverness county, N.S.; clay, from Coal Measures at Hussey Drift, Inverness county, N.S.; clay shale, Port Hood, Inverness county, N.S.; clay, Shaw's brickyard, Middleton, Antigonish county, N.S.; clay, with sandy partings, Shaw's brickyard, Antigonish county, N.S.; clay, Annapolis brickyard, Annapolis county, N.S.; clay, Joggins main seam, Joggins Mines, Cumberland county, N.S.; shale, Pugwash, Cumberland county, N.S.; clay, Moncton, Westmorland county, N.S.; shales overlying oil-shales, south branch of Frederic brook, Albert Mines, Albert county, N.B.; red shales, Weldon brook, Albert Mines, Albert county, N.B.; clay, Lee's brickyard, St. John, N.B.; clay, Mooney's brickyard, St. John, N.B.; shale overlying coal, Grand Lake coal basin, Queens county, N.B.; shale, Pipe-line trench, National Transcontinental railway at Chipman station, Queens county, N.B.; clay, Miller's brickyard, Elmsdale, Hants county, N.S.; clay, Enfield Pottery, Enfield, Hants county, N.S.; ornamental tile, Hornby brickyard, Charlottetown, P.E.I.; firebrick, from clay at Shubenacadie, Hants county, N.S.; firebrick, from underclay at Shubenacadie, N.S.; silica-brick, made by the International Coal Mining Company at Westville, Pictou county, N.S.; stiff mud brick, Maritime Clay Works, Pugwash, Cumberland county, N.S.; stiff mud brick, Miller's brickyard, Shubenacadie, Hants county, N.S.; soft mud brick, Middleton Clay Working Company, Middleton, Annapolis county, N.S.; soft mud brick, underburned, Shaw's brickyard, Avonport, Kings county, N.S.; soft mud brick, well burned, Shaw's brickyard, Avonport, Kings county, N.S.; green brick, underburned, Shaw's brickyard, Avonport, Kings county, N.S.; stiff mud brick, The Buckler Brick Company, Annapolis, N.S.; stiff mud brick, John Lee & Company's brickyard, St. John, N.B.; stiff mud brick, re-pressed, John Lee & Company's brickyard, St. John, N.B.; soft mud brick, Mira Brick Company, Mira river, Cape Breton county, N.S.; brick, M. Ryan & Son, Fredericton, N.B.

Mr. W. W. Leach:—

Three samples of coal, from points near the head of the Skeena river, British Columbia; a series of gold and silver ores, from the Skeena River Mining division, Cassiar district, British Columbia.

Mr. O. E. Le Roy:—

Crystals of calcite, from the Granby mines, Phœnix, B.C.

Mr. R. G. McConnell:—

Nugget of native copper, Burwash creek, Yukon; limestone, from Texada island, B.C.

Mr. A. T. McKinnon:—

Tetrahedrite in fluorite, from lot 1, concession IV, township of Madoc, Hastings county, Ont.; fluorite with incrustation of barite, from the same locality; celestite, from lot 2, concession VIII, township of Lansdowne, Leeds county, Ont.; agate, from Partridge island, Cumberland county, N.S.; calcite, from Five Islands, Cumberland county, N.S.; marble, from the township of Faraday, Hastings county, Ont.; quartz, muscovite, and uraninite, from the Villeneuve mine, township of Villeneuve, Labelle county, Que.; albertite, from Albert Mines, Albert county,

N.B.; molybdenite and molybdite, from the township of Egan, Ottawa county, Que.; diopside, from the township of Cardiff, Haliburton county, Ont.; albite, from the township of Wicklow, Hastings county, Ont.; blue calcite, from the township of Lynedoch, Renfrew county, Ont.; staurolite, from Pubnico, Yarmouth county, N.S.; damourite and fluorite, pseudomorph after tourmaline, from the Villeneuve mica mine, township of Villeneuve, Ottawa county, Quebec; pentlandite, from the Krean Hill mine, township of Denison, Nipissing district, Ont.

Mr. W. J. Wilson:—

Contorted crystals of apatite, from Carp, Carleton county, Ont.

Mr. M. E. Wilson:—

Auriferous quartz, from the Kerr-Addison mine—claim H.S. 165—Larder lake, Nipissing district, Ont.

PURCHASES.

Gold nugget, from Slate creek, Dease river, Cassiar district, B.C.

The 'Big Skookum' meteorite.—This meteorite was uncovered at a depth of 65 feet in the gold-bearing gravels on claim No. 7, Big Skookum gulch, Bonanza creek, Yukon, by Mr. W. Kast, on January 21, 1905. It was exhibited at the Alaska-Yukon-Pacific Exposition at Seattle, Washington, U.S.A., where it was secured by Mr. R. L. Broadbent.

In form it is, roughly speaking, a block varying in thickness from 3 to 8 centimetres, and exhibiting an irregular pentagonal outline; it measures 29 centimetres in length by 23 in width, and weighs 15·88 kilogrammes. The skin is well preserved, is smooth and somewhat glossy, and has a brownish-black colour. The specimen is exteriorly characterized by a number of broad and shallow depressions: one of which has a breadth of 21 centimetres, with a maximum depth of 2 centimetres. In some instances these depressions give to the edges of the specimen a more or less crescentic form; and they are further marked by abundant small pittings or pesographs. The classification of this meteorite is as yet unknown, as it has not been cut into, much less examined internally. By kind permission of Dr. James Bonar, the Deputy Master, there has been executed at the Royal Mint, under the superintendence of Mr. A. H. W. Cleave, a very fine model in metal, which has also been added to the Museum collection.

**The following additions have been made to the collection of foreign minerals.**

DONATIONS.

Messrs. Powers, Weightman, and Rosengarten, Philadelphia, Pa., U.S.A.:—

Epsomite, from the vicinity of Oroville, Washington, U.S.A.

Mr. L. C. Morganroth, Pittsburgh, Pa., U.S.A.:—

Magnesite, from Hungary.

EXCHANGES.

Mr. W. A. Franks, Gunnison, Colorado, U.S.A.:—

Carnotite and roscoelite, from Telluride, Colorado; rubellite with lepidolite, from San Diego, California; sphalerite, from Joplin, Mo.; malachite, from Uinta, Utah; stephanite with malachite and horn silver, from Pilkin, Colorado; scoria and pale amazonite, from Gunnison, Colorado; lepidolite, from Cañon City, Colorado; native tellurium, from Vulcan,

Colorado; zircon, from Cache, Oklahoma; bornite, from Bisbee, Arizona; copper ore, from the Copper Queen mine, Douglas, Arizona; tourmaline in mica, from Parkesburg, Colorado.

South Australian School of Mines and Industries, Adelaide, South Australia:—

Vanadic ochre, from Leigh creek, South Australia; crocodite, from Hawker, South Australia; ullmannite, from Gilles Bluff, Mount Lyndhurst, South Australia; carnotite, from Olary, South Australia; atacamite, from Mutooroo mine, South Australia; blue corundum in mica schist, from Mount Paynter, South Australia; magnesite, from Osmond mine, Gilles Glen, South Australia.

Rhodesia Museum, Buluwayo, Rhodesia:—

Chrysotile, from Shashi river, Victoria, Mashonaland; muscovite, from Selukwe, Rhodesia; microcline, from Selukwe, Rhodesia; barytes, from Kwekwe river, near Gwelo, Rhodesia; semi-opal, from Buluwayo; epidote in aplite, from Buluwayo; scheelite, from King mine, Umswezwe, Rhodesia; amethyst, from Syringa, Rhodesia; wolfram, from Essexvale, Rhodesia; auriferous pyrites, from Valley mine, Gwanda; chalcedony, from Charter, Mashonaland; yellow ground, from Bembezi Diamond Pipes; tourmaline in quartz, from Salisbury, Rhodesia; mispickel, from Victoria, Rhodesia; stibnite, from Gatuma, Rhodesia; molybdenite in quartz, from Gadzema, Rhodesia; auriferous copper-pyrites, from Valley mine, Gwanda; vanadite on bone breccia, from Broken Hill mine, Northwest Rhodesia; agate, from Charter, Mashonaland; copper-bearing sandstone, from Kasempa, Northwest Rhodesia; chrysocolla, from Northwest Rhodesia; granular chromite, from Selukwe, Rhodesia; siliceous sinter, from the Zongala geyser, Sibungwe, Rhodesia; compact chromite, from Selukwe, Rhodesia; auriferous irridescent limonite, from the Falcon mine, Charter, Mashonaland; gold in quartz, from the Gulong mine, Gwanda; diamond-bearing wash, from Somabula; limonite, pseudomorph after pyrite, from Bembezi; cassiterite in decomposed granite, from the Bushwell mine, Transvaal; auriferous chlorite, from the Bell mine, Kwekwe; stream tin, from Bussanga, Congo Free State.

## REPORT OF SPECIAL COLLECTIONS MADE FOR THE ALASKA-YUKON-PACIFIC EXPOSITION, SEATTLE, WASHINGTON, U.S.A., JUNE-OCTOBER, 1909.

*(R. L. Broadbent.)*

In February, 1909, I received instructions from the Director of the Geological Survey to proceed to the Province of British Columbia for the purpose of collecting and preparing a representative series of the minerals of the Province for display at the Alaska-Yukon-Pacific Exposition at Seattle, Washington, U.S.A. I was also instructed to remain in charge of the exhibit during the Exposition.

In accordance with these instructions, I left Ottawa on February 15; and between this date and May 8, all the more important mining districts of the Province were visited. In connexion with my duties, I was accorded the hearty co-operation of the Provincial Department of Mines, the various Boards of Trade, and the mine and smelter managers; while Mr. G. O. Buchanan of Kaslo was at particular pains to secure a very fine exhibit from the Nelson, Slocan, and Ainsworth Mining divisions. The installation of the exhibit was completed in time for the opening day of the Exposition, and I remained in charge of the Canadian Mineral Section until the close, returning to Ottawa on November 13.

The Canadian Mineral Section occupied an area of 18,000 square feet; 10,000 square feet of which was devoted to the exhibits from British Columbia. With the exception of the structural materials, everything was shown under glass: a method by which the specimens were kept uniformly bright and clean during the whole course of the Exposition.

The extensive and varied exhibits of ores and minerals from British Columbia, together with those of smelter products made by the Tyee, Granby, B.C., and Trail Smelting Companies, naturally attracted a great deal of attention. The display made in connexion with the latter Company's exhibit was very attractive, and included specimens of the ore as taken from the mine; the concentrates made therefrom; as well as different products obtained in successive smelting operations up to and including pig-metal, bullion, etc. Large specimens of ore from the Centre Star, War Eagle, and other mines of the Boundary district, also from the St. Eugene mine, Moyie, East Kootenay, were shown by this Company. The exhibit from the last mentioned locality embraced two specimens of silver-lead ore, weighing over a ton each.

The Marble Bay mines, Texada island, were represented by a very interesting series: which embraced some fine examples of bornite with native silver taken from the 960 ft. level—910 feet below sea-level.

A fine collection of the auriferous ores and associated rocks and minerals of the Nickel Plate mine, Hedley, B.C., together with a plan showing a section of the ore-body, and a plan of the Reduction mill, was furnished by Mr. M. K. Rodgers of Seattle, who has since presented it to the Museum.

In addition to the foregoing, the following mines in British Columbia were also represented: Bluebell, Arlington, Ruth, and Emerald claims in the Kootenay district—by large specimens of silver-lead ores; the Mollie Hughes, Krao, Elkhorn, Prince Henry, and Jewel claims of the Boundary district—by ores carrying native silver; the Ikeda Bay mines, Queen Charlotte islands, and the Hidden Creek mine, Observatory inlet, Portland canal—also by ores containing native silver; and a number of claims in the Queen Charlotte, Atlin, and Skeena River Mining divisions—by copper-gold and silver-lead ores.

Amongst the exhibits of metalliferous ores and their products, there was an extensive collection from the districts about Cobalt and Sudbury, in the Province of Ontario: this included rich silver ores from the former district, and copper and nickel ores from the latter; while displays of the metallurgical products of these ores—complete in every detail—as prepared by the Canadian Copper Company, and the Mond Nickel Company, added further interest to the exhibit.

Over $10,000 worth of native gold was shown in four table cases. This exhibit included a very fine collection of British Columbia gold nuggets, secured by the Dominion Assay Office at Vancouver; gold dust and nuggets from Yukon; and gold-bearing quartz from Nova Scotia.

The asbestos industries of the Eastern townships of the Province of Quebec were represented by an extensive display, which attracted particular attention from the general public. The modes of occurrence of this mineral were clearly shown in a number of large blocks, which were the subject of frequent inquiry on the part of visitors.

The mica industries were well represented by a series of specimens from Ontario and Quebec, together with a fine collection of finished products made from like materials.

The display of British Columbia marbles in this section indicated a marked advance in this industry in the Province, and included some very handsome polished specimens from Nootka Marble quarries, Nootka sound, west coast of Vancouver island, and from the Marblehead quarries, Marblehead and Gillett's quarry, Kootenay lake, West Kootenay.

In the division devoted to coals, all the principal British Columbia fields were represented. These were uniformly arranged in pyramids, 4'-6" high. The names of the mines represented will be found at the end of the accompanying list.

The Electric Reduction Company of Buckingham, Quebec, furnished a fine exhibit of ferro-chrome, ferro-silicon, and ferro-phosphorus.

The Mines Branch of the Department of Mines, Ottawa, furnished an interesting exhibit, illustrating the reduction of iron from its ores by the electro-thermic process.

An exhibit of fireclay and its products, from the works at Clayburn, B.C., was made by the Vancouver Fireclay Company, and was very favourably commented upon. There was also an exhibit of cupels and magnesite-brick for electric furnaces, prepared from the magnesite of Atlin, B.C.

The total attendance at the Exposition was 3,740,551.

The following is a list of the specimens collected in the Province of British Columbia:—

## Ores and Minerals of British Columbia.

### ORES FROM ATLIN, B.C.

Native copper—Torres channel. Wm. C. S. Hathorn.
Auriferous quartz—Imperial mines.
Auriferous quartz—Engineer mine.
Cobalt bloom (erythrite)—Pat. Gallagher.
Galena, blende, and pyrite—Wm. C. S. Hathorn.
Chalcopyrite—Lavardiere Bros.
Bornite, and chalcopyrite—Lavardiere Bros.
Blende, and galena—Taku Arm. J. Dunham.
Galena, and chalcopyrite—Atlin. Capt. Alexander.
Azurite, and malachite—Robert Grant.
Galena (argentiferous)—Big Cañon group.
Fourth of July creek—Tom Vaughan.
Native copper—Atlin. Lavardiere Bros.
Chalcopyrite—Atlin. Lavardiere Bros.
Galena—Norman Fisher.
Tetrahedrite—Lavardiere Bros.
Gold and silver ore—Boulder mountain. W. C. S. Hathorn.
Chalcopyrite—Juan river. Ben Nichols.
Stibnite (antimony ore)—Atlin. J. Fox.
Galena with chalcopyrite—Brown group.
Gold-copper ore—Taku Arm. Thos. Kirkland.
Nickel ore—Spruce mountain. Major Neville.
Auriferous quartz—Atlin. Wm. Gass.
Auriferous quartz—Boulder mountain.
Auriferous quartz—Juan river. Larry O'Connor.
Magnetite with chalcopyrite—Atlin.
Auriferous quartz—Boulder mountain. Jas. Clarke.

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Coal—vicinity of Atlin.

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Magnesite—Atlin. David Gibb, Vancouver, B.C.

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BRITISH COLUMBIA COPPER COMPANY'S EXHIBIT, GREENWOOD, B.C.

1. Chalcopyrite and pyrite—Mother Lode mine, Deadwood Camp.
2. Magnetite and pyrite— " " "
3. Magnetite— " " "
4. Ore in calcite gangue— " " "
5. Pyrite and chalcopyrite— " " "
6. Impregnated country rock: largely actinolite with scattered copper sulphides.
7. Country rock: greenstone.
8. Ore with garnetiferous gangue.
9. Actinolite.
10. Copper-gold ore, garnetiferous gangue—Oro Denoro mine, Summit Camp.
11. Galena and blende—No. 7 mine, Central Camp.
12. Copper-gold ore—Emma mine, Summit Camp.
13. Copper-gold ore—Lone Star and Washington mine.
14. Blister copper: slag—B. C. smelter.

Silver ore—Jewel mine, Sally mine, Prince Henry mine, and Elkhorn mine. Greenwood Mining division.

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EXHIBIT OF CONSOLIDATED MINING AND SMELTING COMPANY, TRAIL, B.C.

1. Specimen of pig lead.
2. Specimen of bullion.
3. Bluestone.
4. Lead piping.
5. Anode.
6. Cathode.
7. High grade copper matte.
8. Low grade copper matte.
9. Copper-gold ores from the Centre Star and War Eagle mines, Rossland (large specimens).
10. Galena, St. Eugene mine, Moyie.
11. Twelve jars concentrates.
12. Roasted lead ore.

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Grand Forks Mining Division, B.C.—

Copper-gold ore—Golden Eagle mine, Smiths creek, Grand Forks Mining division, B.C. R. K. Almond, Grand Forks.

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ORES FROM THE OSOYOOS MINING DIVISION.

Mineral specimens from Camp Hedley: arsenopyrite (auriferous)—Metropolitan claim. Kingston Gold and Copper Mining Company.

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Chalcopyrite with pyrrhotite and arsenopyrite—War Horse claim, Kingston group. Kingston Gold and Copper Mining Company.

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Pyrite, arsenopyrite, zinc blende, and chalcopyrite—Golden Zone group, 11 miles from Hedley. Golden Zone Mining Company.

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Chalcopyrite, pyrite, and pyrrhotite—Apex group. Colonial Gold Mining Company—W. D. McMillan, Vancouver, B.C.

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Zinc blende and galena—Similkameen claim, Crown Point group (No. 2); arsenopyrite, Wellington group; pyrite and chalcopyrite, Cannon Ball group. F. Bailey, Merritt, B.C.

Arsenopyrite (auriferous) and associated rocks, Sunnyside No. 3 incline of the Nickel Plate group. Daly Reduction Company.

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Gold-copper ore—Bullion group, near Olalla.

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EXHIBIT FROM THE NICKEL PLATE MINE, HEDLEY, B.C.

*M. K. Rodgers, Seattle.*

1. Average ore as it goes to stamps.
2. Concentrates—gold, 8·70 ozs.; silver, 0·50 oz.
3. Tailings from vanners to cyanide plant.
4. Screened tailings after cyanide treatment, ore 60 mesh—0·12 oz. gold; 0·40 oz. silver.
5. Screened tailings after cyanide on 100 mesh—0·08 oz. gold, 0·3 oz. silver.
8. Screened tailings through 200 mesh after cyaniding—0·05 oz. gold, 0·04 oz. silver.
9. Screened tailings through 200 mesh after cyaniding—0·02 oz. gold, 0·01 oz. silver.
10. Nickel Plate ore—$SiO_2$, 85 per cent; Fe, 5 to 9 per cent; SO, 9 per cent.
11. Typical ore—4·1 ozs. gold; 1·2 ozs. silver.
12. Typical ore showing free gold—1·2 ozs. silver.
13. Monzonite—Nickel Plate mountain.
14. Andesite, phenocrysts of hornblende, plagioclase, in matrix of magnetite, quartz, and hornblende.
15. Rhyolite dike in ore body. Phenocrysts of orthoclase, plagioclase, quartz, hornblende. In matrix, orthoclase, quartz, calcite, apatite, enstatite, and hornblende.
16. Section of ore body.
17. Plan of reduction mill.

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ORES FROM THE KAMLOOPS MINING DIVISION.

Galena—Tartar claim, Cottonbelt mines. E. A. Bjorckman.
Pyrite, chalcopyrite, and bornite—Iron Mask mine, Coal hill. Kamloops Mines, Limited.
Chalcopyrite—Monte Carlo claim, Coal hill. J. G. Rogers.
Chalcopyrite and pyrite—Iron Mask Mine, Coal hill. Kamloops Mines, Limited.
Chalcopyrite and pyrite from 500 ft. level.
Pyrite and chalcopyrite—Iron Cap mine, Kamloops.
Gypsum—Grande Prairie. W. A. A. Warren.
Chalcopyrite and pyrite—Kimberley group, Kamloops. A. Beckman.

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ORES FROM THE NICOLA MINING DIVISION.

Bornite and chalcopyrite—Peacock group. T. Hunter.
Limonite—Chalybeate claim. Robert Pollard, Nicola.
Chalcocite—Big Sioux claim, Aspen Grove. C. Schmidt.
Melanterite—Parrot claim. Frank Bailey, Merritt.
Chalcocite—Aberdeen claim, Tenmile creek. Broomhead Syndicate, Nicola.
Chalcocite—Stand-by-for-Action claim, Tenmile creek.
Chalcopyrite—Copper King claim, Coutlee, Nicola valley. Robt. Waitshoair.
Chalcopyrite—Vancouver group, Aspen Grove. Shatford, Allan, and Co.

Chalcocite—New Westminster claim. Shatford, Carrington, and Co.
Native copper—Golden Sovereign group, Aspen Grove. Lowe and Brown.
Chalcocite—Bear Mountain group, Aspen Grove. Murray Bros. and Starwalt.
Native copper—Bluebell group, Aspen Grove. Lowe and Brown.
Chalcopyrite—Stubbles group, Lower Nicola. Stubbles Co.
Bornite—I.X.L. claim, Tenmile creek. Collis, Graham, and Co.
Bornite—U.X.L. claim of the I.X.L. group, Tenmile creek.

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Native copper—Golden Sovereign claim, Aspen Grove, B.C. J. P. McConnell, Vancouver.

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Quartz (au and ag)—Toto claim. F. Bailey.
Specularite—Manchester claim, Tenmile creek. John Clapperton.

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Native copper—Aspen Grove. Frank Bailey, Merritt, B.C.

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Column and slabs of marble—Nootka Marble quarries, Vancouver island. Nootka Marble Quarries, Limited, Victoria.

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ORES FROM THE FORT STEELE MINING DIVISION.

Galena—North Star mine, Fort Steele Mining division. North Star Mining Co., Limited, Kimberley.
Galena—Stemwinder mine, Fort Steele Mining division. North Star Mining Co., Limited, Kimberley.
Two specimens of ore from the Grace Dore claim, Fort Steele Mining division.

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Natron—Goodenough lake, Lillooet. F. Soues, Gold Commissioner, Clinton, B.C.

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Kaolin and alunite—Kyuquot, west coast Vancouver island. W. F. Gibson, Vancouver.

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Marble (three 10 inch cubes)—Marblehead quarries, Marblehead, B.C. Canadian Marble Works, Limited, Nelson, B.C.

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Marble (10 inch cube)—Kootenay lake, B.C. W. G. Gillette, Nelson, B.C.

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Marble (column and pedestal)—Nootka Marble quarries, west coast of Vancouver island, B.C. Nootka Marble Quarries, Limited, Victoria.

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Sandstone (10 inch cube)—Denman island, B.C. Denman Island Stone Company, Vancouver.
Granite—Granite island, Blind bay, New Westminster Mining division, B.C. Kelly and Murray, Vancouver.

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Brick and clay—New Westminster, B.C. E. J. Fader, New Westminster.

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Sandstone (10 inch cube)—Hornby island, B.C. F. F. Murray, Vancouver.

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ORES FROM THE NELSON, AINSWORTH, AND SLOCAN MINING DIVISION.

| Character of Ore. | Mine. | Location. | Owner. | Address. |
|---|---|---|---|---|
| Copper-Gold ore | Arlington (E.) | Erie | Hastings, E. S | Nelson. |
| Silver-Lead | Bosun | Slocan | Bosun M. Co | N. Denver. |
| Silver-Lead | California | " | C. & C. S. L. M. Co | " |
| Silver-Lead | Wakefield | " | Wakefield Mines | Silverton. |
| Silver-Lead | Silver Bell | " | Prospect only | |
| Silver-Lead | Fisher Maiden | " | F. Maiden M. Co | " |
| Silver-Lead | Last Chance | Sandon | S. Cond M. Co | Nelson. |
| Silver-Lead | Enterprise | Slocan | E. M. C | " |
| Silver-Lead | Alpha | " | McNaught Bros | Silverton. |
| Silver-Lead | Hewitt | " | H. M. Co | " |
| Silver-Lead | Mountain Chief | " | G. W. Hughes | Sandon. |
| Silver-Lead | Mountain Boomer | " | Brandon Bros | Silverton. |
| Silver-Lead | Galena Farm | " | | " |
| Silver-Lead | Standard | " | G. H. Aylard | N. Denver. |
| Silver-Lead | Noonday | " | | " |
| Silver-Lead | Vancouver | " | Vanroi M. Co | Rossland. |
| Silver-Lead | Hampton | " | | |
| Silver-Lead | Emily Edith | " | M. S. Davys | Nelson. |
| Gold ore | Foghorn | Ymir | | |
| Gold ore | Wilson | " | | |
| Gold ore | Arizona | " | | |
| Silver ore | Hunter V | " | J. J. Campbell | " |
| Zinc blende | Molly Gibson | Kokanee | LaPlata Min. Co | " |
| Gold ore | Echo | Sheep creek | | |
| Gold ore | Chio | Ymir | | |
| Gold ore | Eureka | " | | |
| Gold ore | Tally Ho | " | | |
| Gold ore | Ballyhoo | Erie | | |
| Gold ore | Fern | Hall creek | Fern G. M. & M | Nelson. |
| Silver-Lead | Emerald | Salmo | John Waldbeser | Salmo. |
| Gold ore | Eureka | Nelson | Anderson Mgr | Nelson. |
| Gold ore | Mica | " | | |
| Silver-Copper | Silver King | " | L. Pratt | " |
| Silver-Lead | Vancouver | Slocan | Van-Roi Mining Co | |
| Gold ore | McEvoy | Ymir | | |
| Gold ore | Ymir Belle | " | | |
| Gold ore | Ore Hill | Salmo | | |
| Gold ore | Ymir | Ymir | Ymir Gold Mining Co | Ymir. |
| Silver ore | Granite King | S. F. Kaslo | J. F. McIntosh, S. Fork, Kaslo creek | Kaslo. |
| Silver ore | Gray Eagle | " | J. F. McIntosh, S. Fork, Kaslo creek | " |
| Blende ore | Province | " | Province Mines, S. Fork, Kaslo creek | " |
| Silver ore | Montezuma | " | M. Mines, S. Fork, Kaslo creek | " |
| Silver ore | Cork | " | Selkirk M. Co | " |
| Silver ore | Revenue | " | L. McLean, S. Fork, Kaslo creek | " |
| Gold quartz | Kootenay Belle | Salmo | J. McMaster | Salmo. |
| Gold quartz | Mother Lode | " | J. McMaster | " |
| Gold quartz | Granite | Nelson | Granite Mines | Nelson. |
| Silver-Lead-Zinc | Blue Bell | Kootenay lake | Can. Metal Co., S. S. Fowler, M. E. Mgr. 4 spec | Riondel. |
| Native silver | Krao | Ainsworth | W. S. Zwicky | Kaslo. |
| Silver-Carbonate | L. H. G. Gal'r | " | A. D. Wheeler | Ainsworth. |
| Iron and gold | Grant | " | | " |
| Silver-Lead | Maestro | " | H. Giegerich | Kaslo. |
| Silver-Lead | Highlander | " | H. M. Co | Ainsworth. |
| Silver-Lead | R. Cariboo | Macguigan | Rambler C. Co | Kaslo. |
| Silver-Lead | Whitewater | Whitewater | W. M. Co | " |
| Zinc | Lucky Jim | Bear lake | G. W. Hughes | " |
| Silver-Lead | Ruth | Sandon | Ruth Mines (3 sps.) | " |
| Silver-Lead | Jackson | Jackson basin | Jackson Mines | " |
| Silver-Lead | Early Bird, | Sandon | J. S. C. Fraser | Rossland. |
| Silver-Lead | Elkhorn | " | J. W. Stewart | Sandon. |
| Silver-Lead | Marie Fraction | " | J. Kelson | " |
| Silver-Lead | Mercury | " | Cunning and others | " |
| Silver-Lead | R. Eureka | " | Can. Con. M. & S. Co | Trail. |

ORES FROM THE NELSON, AINSWORTH, AND SLOCAN MINING DIVISION—*Continued.*

| Character of Ore. | Mine. | Location. | Owner. | Address. |
|---|---|---|---|---|
| Silver-Lead...... ... | Neglected ... ..... | Sandon......... | Black & Cameron............ | Sandon. |
| Silver-Lead......... | S. Sovereign....... | " ......... | C. F. Ranson............... | " |
| Silver-Lead....... | Ivanhoe ............ | " ......... | Minn. S. M. Co.............. | " |
| Silver-Lead... ... | Tamarac. ...... .... | Springer creek.. | G. Henderson ............... | Slocan City. |
| Silver-Lead-Gold... | Phœnix. ......... ..... | " .... | G. Henderson ............... | " |
| Silver-Lead......... | Hamilton........... | Twelvemile creek | Ralph Gillet................. | " |
| Silver-Lead......... | Deadwood .......... | Springer creek.. | Angus McVicar ...... ...... | " |
| Silver-Lead... . .. | Cal. and Hecla...... | " .... | W. M. Clement.............. | " |
| Silver-Lead-Gold... | Morning Star..... | " .... | W. M. Clement.............. | " |
| Silver-Lead......... | Thora ............. | Tenmile creek .. | D. McCuaig................. | " |
| Silver-Lead......... | Red Fox.......... | Sandon......... | G. Henderson............... | " |
| Silver-Lead....... . | Arlington (S.).. . . | Slocan.......... | Arlington Mines ............ | " |
| Silver-Gold......... | Ottawa.............. | Springer creek .. | Ottawa M. Co............... | Nelson. |
| Native silver........ | Molly Hughes ...... | Slocan.......... | M. Zattoni................ | N. Denver. |
| Gold-Silver-Lead... | Yankee Girl........ | Salmo .......... | Y. G. M. Co ............... | Salmo. |
| Antimony .......... | .... ........... ... | .............. . | Stmr. Slocan.... .......... | Slocan Lake. |
| Gold ore............ | Nugget mine........ | Sheep creek, Nelson........... | A. Gracey.................. | Nelson. |
| Gold ore........... | Eureka mine. ... .. | Fortynine creek. | .............................. | " |

Free milling gold quartz—Cholla group, Lardeau Mining division, Camborne, B.C. Imperial Division Syndicate.

Free milling gold quartz—Eva mines. Eva Gold Mines, Limited, Camborne, B.C.

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Silver ore, Silver Cup—Trout Lake Mining division. F. C. Merry, Ferguson.

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Portland cement—Victoria, B.C. Vancouver-Portland Cement Company.

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Crude petroleum—Flathead river, East Kootenay, B.C. Bureau of Mines, Victoria, B.C.

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Gypsum—Thompson river, opposite Spatsum, Canadian Pacific railway. Sinclair Spencer, Vancouver.

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GOLD, COPPER, AND SILVER ORES FROM THE QUEEN CHARLOTTE MINING DIVISION.

Chalcopyrite—Copper Queen mine, Jedway.
Bornite and chalcopyrite—Swede group, Lockeport.
Chalcopyrite—Lily group, Ikeda bay.
Chalcopyrite—Oceanic mine, Collison bay.
Magnetite with chalcopyrite and pyrite—Reco mine, Harriet harbour, Jedway.
Magnetite with chalcopyrite and pyrite—Modoc mine.
Bornite—Last Chance claim, Lockeport.
Chalcopyrite—Thunder mine, Collison bay.
Chalcopyrite and pyrrhotite—Contact group, Tasoo harbour.
Magnetite and chalcopyrite—Maggie C claim, Huston inlet, Jedway.
Bornite—North Star claim, Gold harbour, west coast.
Chalcopyrite—Peerless group, Carpenter bay.
Chalcopyrite and bornite—Bismark claim, Lockeport.
Chalcopyrite—Trust mine, Copper island.
Chalcopyrite—Moresby Island mine, Jedway.
Chalcopyrite—Iron group, Huston inlet, Jedway.
Chalcopyrite—Gold Cliff mine, Huston inlet, Jedway.
Chalcopyrite—Iscoyd mine, Huston inlet, Jedway.

Pyrite—Arctic Robin group, Lockeport.
Chalcopyrite and pyrite—Meal Ticket mine, Collison bay.
Chalcopyrite—Warwick group, north slope of Moody mountain, south side Tasoo harbour. Tasoo Mining and Smelting Company, Tasoo harbour.
Chalcopyrite and pyrite—Ikeda Bay mine, Ikeda bay.
Chalcopyrite—Moody mine, Tasoo harbour. Elliott Mining Company.

GOLD-COPPER ORES FROM THE SIMILKAMEEN MINING DISTRICT.

Chalcopyrite and pyrite—Copper mountain. E. F. Voight.
Chalcopyrite and pyrite—Canadian Belle claim. McRae Bros.
Auriferous quartz—Granite claim, Granite creek.
Chalcopyrite—Oriole claim, Copper mountain. Snowdon Bros. and Day.
Gold-copper ore—Copper mountain. E. F. Voight.
Auriferous quartz—Gold Crown claim, Granite creek, east slope. Fitzgerald Bros. Ledge, 2 feet.
Gold-copper ore—Triangle claim, Copper mountain. Thomas Bros., Princeton.
Chalcocite—Voight Camp, Similkameen. McRae Bros.
Copper ore—Azurite claim, Voight Camp. McRae Bros.
Chalcopyrite—Oriole No. 2 claim, Copper mountain. Snowdon Bros. and Day, Princeton.
Chalcopyrite—Copper Farm, Copper mountain. Sanders and Millar.
Chalcopyrite—H. H. Gardner claim, Copper mountain. Sanders and Millar.
Chalcopyrite—Sunrise claim, Copper mountain. Burr and Jones.
Chalcopyrite—Reco claim, Copper mountain. Bank of Montreal.
Chalcopyrite—Jenny Silkman claim, Copper mountain. French and Day.
Chalcopyrite—Silver Dollar claim. Cramer and Bryant.
Copper-gold ore—Red Eagle No. 2 claim, Copper mountain. E. A. Thomas, Princeton.
Chalcopyrite—Princess May claim. Charles Powell.
Bornite—Smuggler claim, Copper mountain. Willarson and Johnson.
Chalcopyrite—Long Jim claim, Fivemile creek, Similkameen. Cox and Uhlan.
Chalcopyrite—Bull Dog claim, Fivemile creek. F. Fracas.
Galena—Skagit, Similkameen. L. Gibson, Princeton.
Chalcopyrite—Stevenson claim, 5 miles below Princeton on river opposite Holmes' ranch, Similkameen. Willarson and Johnson.
Chalcopyrite—Mogul No. 1, Kennedy mountain, Similkameen.
Chalcopyrite—Gladstone claim, Friday creek. F. M. Gillespie, Hedley.
Chalcopyrite—Blue Ridge claim, Fivemile creek. Cox and Uhler.
Galena with pyrite—Summit. R. Stevenson, Princeton.
Chalcopyrite—Red Buck claim, Kennedy mountain. Allison and Revely.
Azurite and malachite—Ada B. claim, Copper mountain. Willarson and Johnson.
Chalcopyrite—Sunset claim, Copper mountain. Sanders and Millar.
Chalcopyrite—Mogul No. 2, Kennedy mountain. Willarson and Johnson.
Chalcopyrite—Red Star claim, Roche river. Powell and Bonnivier.
Bornite—Gladstone claim, Friday creek. Wheeler *et al.*
Coal—Princeton (24 ft. seam). Vermilion Forks Mining Company.
Coal—West Fork of Granite creek. Empire Development Company.

EXHIBIT OF THE GRANBY CONSOLIDATED MINING, SMELTING, AND POWER COMPANY, GRAND FORKS, B.C.

Gold-copper ores from Phœnix, and blister copper from the Smelter, Grand Forks.

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Gold-copper ore—Le Roi mine, Rossland, B.C., from the 600 and 1,650 ft. levels; two specimens. Le Roi Mining Company, Limited, Rossland.

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Gold-copper ore—Hamilton vein, Josie mine, Rossland, 500 ft. level; East Hamilton vein, 300 ft. level; West Hamilton vein, 500 ft. level. Le Roi No. 2 Mining Company, Limited.

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ORES FROM BEAR RIVER, PORTLAND CANAL, SKEENA RIVER MINING DIVISION, CASSIAR, STEWART MINING AND DEVELOPMENT COMPANY, VICTORIA, B.C.

1. Pyrite with galena and native silver—Lucky Seven and Little Joe claims, Glacier creek. Portland Canal Mining Company, Duncans, B.C.
2. Pyrite with galena—Geo. E. and Ben Hur claims, Glacier creek, Bear river.
3. Galena and blende—Glacier creek, Bear river.
4. Galena and blende—Main reef, Glacier creek, Bear river.
5. Galena, blende, and chalcopyrite—Rainier claim, Bear river.
6. Galena—Maybee claim, American creek.
7. Chalcopyrite, blende, and bornite—Bandolier claim, American creek.
8. Chalcopyrite—London group.
9. Molybdenite—Observatory inlet.

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Pyrite and galena (auriferous and argentiferous)—Gipsy claim. Portland Canal Mining Company, Duncans, B.C.

Pyrite and galena with native silver—Lucky Seven and Little Joe claims, Glacier creek. Portland Canal Mining Company, Duncans, B.C.

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Ores of gold and silver from the O.K. and Little Wonder claims. Pereault and Chapman, Stewart, B.C.

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Chalcopyrite and pyrite—Hidden creek, Goose bay, Observatory inlet, B.C. M. K. Rodgers, Seattle.

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Gold-copper ore—Maple Bay mine, Portland canal, B.C. Wm. Noble, Vancouver.

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EXHIBIT OF THE TYEE COPPER COMPANY, LIMITED, VICTORIA, B.C.

1. Ore from the Britannia mine—Howe sound.
2. Ore from the Cornell mine—Texada island.
3. Ore from Valdez island.
4. Ore from Sydney inlet (Indian Chief mine).
5. Ore from Prince of Wales island.
6. Specimen of copper matte made from the above ores by the Tyee Copper Company. Forty per cent copper.
7. Ore from the Arctic Chief, Whitehorse, Y.T.
8. Ore from Ikeda Bay mines, Queen Charlotte islands.
9. Ore from the Pueblo mine, Whitehorse, Y.T.
10. Three copper ingots made from ore smelted at the Tyee smelter, Ladysmith.
11. Photos of smelter and shipping pier, Ladysmith, B.C.

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Chalcopyrite and pyrite—from the Jane mine, Britannia Beach, Howe sound. Britannia Mining and Smelting Company, Limited, Britannia Beach, B.C.

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Iron pyrites—Ecstall inlet, Skeena river, B.C. B.C. Pyrites Company, Victoria, B.C.

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Arsenopyrite—Bonanza mine, Hope, Yale Mining division. Victor George, Hope.

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ORES FROM TEXADA ISLAND.

Bornite—Little Billy claim, Texada island. J. T. Taylor, Van Anda.
Pyrite and chalcopyrite—Florence Case, Texada island. J. T. Taylor, Van Anda.
Chalcopyrite—Loyal lease, Texada island. James Raper, Van Anda.
Chalcopyrite and bornite—Loyal lease, Texada island. James Raper, Van Anda.
Bornite—Rose and Bell claim, Texada island. James Raper, Van Anda.
Iron ochre—Iron Crown claim, Texada island. P. A. Staaf, Van Anda.
Bornite, chalcopyrite, and native silver—Marble Bay mine, Texada island, B.C., 960 ft. level. Tacoma Steel Company, Van Anda, B.C.
Bornite and chalcopyrite—Cornell mine, Van Anda, Texada island, 360 ft. level. Northern Texada Mines, Limited, Vancouver.

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ORES FROM VANCOUVER ISLAND, V.I. DEVELOPMENT LEAGUE, VICTORIA, B.C.

Clay ironstone—No locality.
Bog iron ore—Quatsino.
Copper ore—Koksilah, Cowichan.
Copper ore—New shaft, Copper Cañon claim, Mount Sicker.
Copper ore—Mounts Sicker and Breton mines, Copper cañon.
Azurite—No locality.
Magnetite—Hesquot.
Magnetite—Sarita river, above Banfield creek.
Antimony—Gordon river, Renfrew district.
Copper ore—Patchena claim, Gordon river.
Cinnabar—West coast, Vancouver island. F. H. Mayhew, Victoria.
Native arsenic—Koksilah.
Copper ore—Virginius claim, Maxwells Peak, Saltspring island. A. F. Gwin.
Zinc blende—Vancouver island.
Graphite—Renfrew district.
Copper ore—Monitor claim, Alberni canal.
Copper ore—Yreka claim, Comstock mountain, Quatsino sound.
Copper ore—Lenora mine, Mount Sicker.
Copper ore—King Solomon mine, Cowichan station.
Auriferous quartz—Elk river, Kennedy lake.
Copper ore—Cascade mountain, Alberni.
Copper ore—Quatsino sound.
Copper ore—Sicker mine, Mount Sicker.
Copper ore—Johns claim, Mount Sicker.
Copper ore—Saltspring island, B.C. Neave Saunders.
Copper ore—Belle mine, Mount Sicker.
Copper ore—Southern Cross mine, Uchucklesit.
Copper ore—Cowichan lake.
Copper ore—Happy John mine, Alberni.
Copper ore—Little May claim, Hettie Green group, Clayoquot, Tofino.

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Gold-copper ore—Blue Bird and Willow Grouse claims, Sooke, Vancouver island. R. F. Tolmie, Victoria.

## Ores from Yukon Territory.

Bornite and chalcopyrite—Copper King mine, Whitehorse.
Bornite in tremolite—Copper King mine, Whitehorse.
Chalcopyrite and bornite in magnetite—Arctic Chief mine, Whitehorse.
Chalcopyrite and azurite with tetrahedrite—Arctic Chief mine, Whitehorse.
Bornite—Anaconda mine, Whitehorse.
Bornite and chalcopyrite—Grafter mine, Whitehorse.
Bornite and chalcopyrite—War Eagle mine, Whitehorse.
Bornite, chalcopyrite, and magnetite—Le Roi mine, Whitehorse.
Bornite and malachite—Keewenaw mine, Whitehorse.
Specular iron with copper carbonates—Pueblo mine, Whitehorse.
Bornite with malachite—Rabbit-foot mine, Whitehorse.
Chalcopyrite—Best Chance mine, Whitehorse.
Chalcopyrite—Valerie mine, Whitehorse. A. B. Palmer, Vancouver.
Bornite—Empress of India mine, Whitehorse.
Chalcopyrite—Valerie mine, Whitehorse.
Galena, sphalerite, and pyrite—Conrad mines, Windy Arm.
Pyrrhotite, sphalerite, and galena—Venus mine, Conrad.

Chalcocite—Arctic Chief mine, Whitehorse.
Chalcopyrite—Valerie mine, Whitehorse.
Copper ore with specularite—Pueblo mine, Whitehorse.
Native copper from White river, Y.T. Capt. John Irving, Victoria, B.C.

Four gold nuggets from Griffith's claim—Wild Horse creek, Fort Steele Mining division, East Kootenay, B.C., 7 ozs. 16 dwts. 8 grains. Geological Survey.

Auriferous gravel—Eldorado creek, containing 5·32 ozs. gold, Klondike, Y.T. Value, $85.

Model of gold nugget—Slate creek, Cassiar, B.C. Geological Survey.
Model of gold nugget—Willow creek, Atlin, B.C. Presented by W. F. Robertson, Provincial Mineralogist, Victoria, B.C.

Auriferous gravel—United mines, Bonanza creek, Adams hill, Y.T. Geological Survey.

Coal and coke—Fernie, B.C. Crows Nest Pass Coal Company, Limited, Fernie, B.C.

Coal—Middlesboro collieries, Nicola valley, B.C. Nicola Valley Coal and Coke Company, Limited, Vancouver, B.C.

Coal—South Wellington, Vancouver island, B.C. Pacific Coast Coal Mines, Limited, Victoria, B.C.

Coal—Suquash, Vancouver island, B.C. Pacific Coast Coal Company, Limited, Victoria, B.C.

Coal—Wellington colliery, Extension, Cranberry district, Vancouver island, B.C. Wellington Colliery Company, Limited, Victoria, B.C.

Coke—Comox mine, Vancouver island, B.C. Wellington Colliery Company, Limited, Victoria, B.C.

Coal—Princeton, B.C. Vermilion Forks Mining Company.

Coal and coke—Coleman, Alberta. International Coal and Coke Company, Limited, Coleman, Alta.

Anthracite and briquettes—Bankhead mines, Alberta. Bankhead Mines, Limited, Bankhead, Alta.

Coal—Granite creek (West fork), Similkameen Mining division, B.C. Empire Development Company.

## ARCTIC EXPLORATION.

*(R. A. A. Johnston.)*

The following specimens collected by Captain J. E. Bernier during the cruise of the Canadian steamship *Arctic* in 1908-9, have been donated to the Museum:—

List of materials contributed by Captain J. E. Bernier from the expedition of 1908-9, November 8, 1909:—

1. Board with instructions indicating the position of Capt. Kellett's depot, Dealy island, Melville island.
2. Record box found in Captain Henry Kellett's depot, Dealy island, Melville island.
3. Pole found on Melville island—Sir Edward Parry—1819-20.
4. Hand bars, Melville island—Sir Edward Parry—1819-20.
5. Maul (ship's), *Resolute*, 1851-3, Melville island.
6. Adze, H.M.S. *Resolute*—Capt. Henry Kellett—1851-3.
7. Eskimo toy, Pond inlet.
8. Rope found Bay of Mercy—*Investigator* expedition, 1850-2.
9. Prayer book, Melville island—Sir Edward Parry—1819-20.
10. Tent peg, Melville island—Sir Edward Parry—1819-20.
11. Lead bullets, Cockburn point, date 1851.
12. Two Eskimo pipes.
13. Polar bear teeth.
14. Fox skulls.
15. Two pieces of rope from Sir John Franklin's monument.
16. Piece of wood from yacht *Mary*—Capt. John Rose—1854.
17. Record box left by Commander A. P. Low.
18. Drift wood, Liddon gulf, found by Reuben Pike, ss. *Arctic*, 1909.
19. Box of teeth, shells, buckles, buttons, etc., Melville island.
20. Piece of porcelain found on Beechy island, September, 1906, relics of the North Star expedition of 1854.
21. Wash-mop, Parry expedition, 1819-20.
22. Record in bottle, whaler *Esquimaux*—Capt. Philips—1891.
23. Wood from Parry expedition, 1819-20.

24. Wood and rope, Cape Haven, Baffinland.
25. Wood, coal, and ivory, Liddon gulf, 1906.
26. Piece of bunk of a boat at Erebus bay, September 2, 1908.
27. Coiled brass shell for some old type of rifle, found at Beechy island, 1906.
28. Piece of pick, found on Cockburn island, 1906.
29. Piece of bone with names of travellers.
30. Bullets of various calibres cut from musk oxen.
31. Two pieces of broken earthenware, Parry's expedition of 1819-20.
32. Glass, nails, etc., from Parry's expedition of 1819-20.
33. Perforated sheet of copper, from one of the sloops left by Franklin, Beechy island.
34. Portions of copper vessel left by William Parry—found on Melville island.
35. Piece of sheet copper, found on Melville island just north of Winter harbour. Relics left by William Parry.
36. Lamp bottom, left by William Parry on Melville island.
37. Tent pegs, left by Capt Sabine on Melville island.
38. Box handle, Melville island; left by William Parry.
39. Rowlock socket, taken from one of the sloops left by Franklin, Beechy island.
40. Two guns, from Depot House of Kellett and McClintock, Dealy island, Melville island.
41. Parts of a thermometer, from the *Resolute* of 1851-3.
42. Piece of a board, from the yacht *Mary*—Sir John Ross—1850-1.
43. Some pieces of board, taken from an old boat, part of Sir Edward Belcher's North Star expedition.
44. McClintock's record box, June 11, 1851.
45. Sweater, found in a cask at Depot House, Dealy island, Melville island, August 31, 1908. J. D. McMillan, ss. *Arctic*.
46. Relics from fireplace of Parry's expedition, Melville island, 1819-20.
47. Books, etc., 19 in number, from the Depot House of H.M.S. *Resolute*—Capt. Henry Kellett—1851-3, Melville island, lat. 75° N. and long. 109° W.
48. Pole stadia, Melville island.
49. Barrel of flour, 360 pounds, from the Depot House of H.M.S. *Resolute*—Capt. Henry Kellett—1851-3.
50. Box ammunition, from the Depot House of H.M.S. *Resolute*—Capt. Henry Kellett—1851-3.
51. Musk ox head.
52. Skin of Northern gyrfalcon.
53. Skin of snowy owl.
54. Skin of loon.
55. Skin of barren ground caribou.
56. Skin of wolf.

Also a collection of minerals, rocks, coal, etc., from points in the Arctic regions visited by Captain Bernier during the cruise of ss. *Arctic* in 1908 and 1909.

## ARCHÆOLOGY AND ETHNOLOGY.

In order to secure adequate office space, it has been found necessary to remove the exhibits in the 'Indian room.' An inventory of these is being taken, and they are being packed for transfer to the Victoria Memorial Museum.

The following additions have been made to the collection during the year:—

DONATIONS.

Mr. Bernhard Marcuse, Montreal:—

Arrowhead, found by Miss Gibson on the shore of Nicolet lake, near Danville, Richmond county, Quebec.

Mr. George C. Holland, Ottawa:—

Two stone axes and a stone gouge, found on Skead's limits, Madawaska river, Ontario.

John L. Retallack, Esq., Kaslo, B.C.:—

Canoe made by the Kootenay tribe of Indians.

Joseph Streit, Esq., Kaslo, B.C.:—

Stone hammer head—Kootenay Indians, Kootenay lake, B.C.

## PALÆONTOLOGY AND ZOOLOGY.

*(Lawrence M. Lambe.)*

My study of the Palæoniscid fishes of the Albert shales of New Brunswick, begun in 1908 and referred to in the Summary Report for that year, was continued during the early part of the past year, and occupied most of my time until June. By that time the manuscript descriptive of these fishes was completed, as were also the drawings and photographs for eleven illustrative plates, the whole forming a monograph on the Albert shales fishes, to be issued as part V, of volume III (quarto), of Contributions to Canadian Palæontology.

A short time toward the end of May was given to the preparation of a paper entitled 'The Fish Fauna of the Albert Shales of New Brunswick.' This paper, illustrated with one plate, appeared in the August number of volume XXVIII of *The American Journal of Science.*

A Bibliography of Canadian Zoology for 1907 (exclusive of Entomology) was written during the early part of the year, and presented at the annual meeting of the Royal Society of Canada for publication in its transactions.

Part IV, of Volume III (quarto) of 'Contributions to Canadian Palæontology' was published in March last, and has since been distributed. This memoir is descriptive of 'The Vertebrata of the Oligocene of the Cypress hills, Saskatchewan,' and consists of 82 pages of letter-press, illustrated by 13 text figures and 8 photogravure plates.

### FIELD WORK.

During the summer of 1909, a month was devoted to field work; the principal object of which was to obtain additional remains of fishes from the lower Devonian rocks of Campbellton, N.B.

Leaving Ottawa on July 12, for New Brunswick, a few days were first spent, in company with Mr. W. J. Wilson, at and near St. John, N.B., where I had been instructed to examine certain Laurentian beds stated to contain spicular remains of sponges. At two localities, one in the city of St. John, on the north side of St. John river, a few hundred yards above the railway bridge, the other at Drury cove, about 4 miles north of the city, occur rocks which have been regarded as of Laurentian age, and which have been so mapped by the Geological Survey. *Halichondrites graphitiferous*, Matthew,[1] has been described from the graphitic shales of the first locality. The quartzites and limestones of the second locality have furnished material for the description of *Cyathospongia* (?) *eozoica*, Matthew,[2] . . . Strict search, made at both of these places, revealed nothing that was recognized as of spicular origin; although in the graphitic shales near the St. John bridge certain markings were observed, which appeared to be of the nature of lines of crystallization, bearing some resemblance to the figure accompanying the description of *Halichondrites graphitiferous.*

Proceeding to Campbellton, a collection was made of the remains of fishes and plants preserved in the lower Devonian rocks, exposed for some distance as low cliffs along the river front, above the town. This collection will form a welcome addition to the material from this locality already in the possession of the Geological Survey; not only as a help in further study of the interesting fauna and flora of these rocks, but also for exhibition purposes.

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[1] Bull. Nat. Hist. Soc. of New Brunswick, No. IX, p. 42, fig. 2, 1890, 'On the Occurrence of Sponges in the Laurentian Rocks at St. John, N.B.'
[2] Idem, p. 43 (with figures).

Later, some time was spent on the north shore of Gaspé bay, where the Gaspé sandstones, forming cliffs eastward from Peninsula, give place at Grande Greve to the underlying Gaspé limestones, which are found outcropping from here eastward to Indian cove. A collection was made of the fossils of the limestones to supplement the specimens in the museum of the Geological Survey, which do not fully represent this particular fauna.

Since March last, the duties of Palæontologist and Zoologist have been performed by the writer. These have included the examination and determination of collections of fossils and recent forms made by officers of the Department, and of others submitted by institutions and individuals. They have also necessitated a large expenditure of time in correspondence, many letters having the nature of reports.

As regards collections, the following have been examined and reported on:—

Mr. Owen O'Sullivan:—

A small collection of fossils made in 1908, on Shamattawa and Severn rivers, and on the south coast of Hudson bay.

Mr. G. A. Young:—

A collection of fossils (principally corals), made in 1908 at Belledune, and at Limestone point, on the south shore of Chaleur bay.

Collections made by Mr. Young in 1909 at Tetagouche river, at two localities near Petite Roche station on the Intercolonial railway, and at Belledune point, Chaleur bay.

Mr. E. R. Faribault:—

A small collection of fossils made in 1907 at a number of localities in Mahone bay, Lunenburg county, N.S.

Mr. W. McInnes:—

A few fossils obtained in 1909, near and to the south of Lac LaRonge, Saskatchewan.

The Dominion Government Arctic Expedition of 1908-9:—

A collection of fossils, recent shells, etc., made by Mr. McMillan, the geologist to the expedition, on Beechy, Melville, Banks, and Bathurst islands. The fossil plants of this collection were determined by Mr. W. J. Wilson.

The Smithsonian Institute, Washington, D.C.:—

A few recent marine sponges, from the coast of British Columbia, submitted by the National Museum.

Mr. W. W. Leach:—

Fossils collected in 1907, in the Skeena River district, B.C., at two localities, viz., Hudson Bay mountain, Zymoetz river; and Bulkley river, 10 miles south of Moriceton.

## ADDITIONS TO THE PALÆONTOLOGICAL AND ZOOLOGICAL COLLECTIONS DURING 1909.

Collections and specimens, as follows, were received from members, and employes, of the Geological Survey:—

Cairnes, D. D.:—

One crushed specimen of an ammonite from near Union mines, Wheaton River district, Yukon. This fossil is clearly referable to the species obtained by Mr. Cairnes in 1906 from Union mines, and determined by Dr. Whiteaves as *Prionocyclus woolgari* (Mantell), Cretaceous.

Camsell, C.:—

A small collection of plants from Tertiary shales (Oligocene), Collins gulch, Tulameen river, B.C. Determined by Mr. W. J. Wilson.

Five specimens of plant-like remains from shales of presumably Triassic age, Slate creek, Tulameen river, B.C.

Ells, S. C.:—

Portions of the rhizomes of *Psilophyton princeps*, Dawson, from Narrows brook, a tributary of York river, 25 miles from Gaspé basin; from grey beds of sandstone belonging to the Gaspé Sandstone series (upper Devonian). The specimens are from a layer, 4 to 5 inches thick, made up entirely of flattened, horizontally disposed rhizomes of this species. They are charged with hydrocarbons, and kindle readily into flames when ignited.

Dowling, D. B.:—

Collections of fossils from the foothills of the Rocky mountains, Alberta, between Saskatchewan and Athabaska rivers, as follows:—

Fifteen fossil shells, from the Cardium sandstone (middle Colorado formation), between Bighorn river and Wapiabi creek, Alberta.

Two fossil shells, from the Kootanie formation, Raven creek—a branch of Saskatchewan river, Rocky mountains.

Five fossil plants, from the top of the Kootanie formation, Raven creek.

Twelve fossil plants, from the upper part of the Cardium sandstone, Taylor creek, a branch of Brazeau river, Alberta.

Two fossil shells, from the Claggett shale, Taylor creek.

Twenty-five fossils (shells and plants), from the Kootanie formation, head of the south branch of McLeod river, Alberta.

Johnston, W. A.:—

About sixty specimens of crinoidea, cystidea, and starfishes, from the Trenton limestone along the Trent Valley canal, near Kirkfield, Ont.

About fifty specimens of fossils, from the supposed Black River and Birdseye (Lowville) limestone, on the west side of Lake Couchiching, Ont.

Lambe, L. M.:—

Graphitic shale, mapped as of Laurentian age, from the north side of St. John river, about 200 yards above the railway bridge, St. John, N.B.

A collection of fish and plant remains, from the lower Devonian rocks of Campbellton, N.B.

A collection of fossils from the Gaspé limestones (Grande Grevé limestone) of the north shore of Gaspé bay, between Little Gaspé and Indian cove.

Leach, W. W.:—

A collection of plant remains, comprising four or five species, from rocks of presumably lower Cretaceous (Kootanie) age, from Twentymile mountain, about 20 miles by trail (or 10 miles in a straight line) northeast of Hazelton, B.C.

Leaves (one specimen), apparently referable to *Sequoia heerii*, Lesq, from Driftwood creek, Bulkley valley, B.C.; collected in 1908. This species has been recorded (Penhallow) from the Tertiary lake deposits of the interior of British Columbia. The shale on which the leaf impressions are preserved, resembles that of the fish, insect, and plant-bearing beds of the Quilchena and Tulameen areas.

Malloch, G. S.:—

Three corals, from the slope of Red mountain, on the north side of Fraser river, B.C., 110 miles above Fort George, from limestone beds which are apparently synchronous with McConnell's 'Intermediate limestone' of the Bow valley, and probably about the age of the Hamilton formation (upper Devonian). Two of the specimens are *Cladopora cervicornis*, de Blainville; the third is fragmentary, and is probably a Cyathophyllum.

McInnes, W.:—

A few fossils from rocks of middle Devonian age (Stringocephalus zone), Lac LaRonge, Saskatchewan.

McKinnon, A. T.:—

One specimen of the recent marine sponge, *Desmacidon* (*Homœodictya*) *palmata*, Johnston, from Two Islands, N.S. This sponge, originally described from Great Britain, is a common form in the waters of the Bay of Fundy, and off the coast of Nova Scotia, as well as the northeast coast of the United States.

Wilson, W. J.:—

A collection, of about 2,000 specimens, of Devonian and Carboniferous plants, from the following localities in New Brunswick: Little Lepreau; Kennebecasis island; Moosehorn brook, Norton; Gardner creek; Tynemouth creek; Cape Enrage; Mary point; Grindstone island; Minto, Grand lake; and Beersville, Kent county.

A few fossils from Trenton beds at the peninsula, west side of Dow lake, Central Experimental Farm, Ottawa, Ont.

Young, G. A.:—

Over thirty pieces of black carbonaceous slate, of Ordovician age, holding graptolites; from the north bank of Tetagouche river, above the crossing of the Intercolonial railway, near Bathurst, Gloucester county, N.B.

A few Silurian fossils, collected on the bank of a stream that is crossed by the Intercolonial railway, about one and a quarter miles north and west of Petite Roche station. The exposure is situated on the stream about 300 yards below the railway crossing.

A few fossils, from a point on the Intercolonial railway about 2 miles north and west from Petite Roche station, and about 300 yards from the locality just mentioned. Silurian.

A small collection of fossils (Silurian), from an exposure of rocks on a small stream at a point slightly over 2 miles nearly due south of Belledune point, south shore of Chaleur bay.

## Additions to the Palæontological and Zoological Collections from other Sources, during the past Year.

### (A.) PALÆONTOLOGY.

By presentation:—

Bernier, Captain:—

Fossil corals, from the Silurian of Erebus bay (Beechey island), southern end of Wellington channel, viz., three specimens of *Acervularia austini*, Salter; and one of *Strephodes pickthornii*, Salter.

Evans, W. B., Manager of the Rothwell Coal Company, Limited, Minto, Sunbury county, N.B. (per W. J. Wilson):—

About twenty well preserved specimens of Carboniferous (Millstone Grit) plants from the Rothwell Coal mine.

Grant, Colonel C. C., Hamilton, Ont.:—

Two fossils from the Clinton formation, and eight from the Niagara chert, at Hamilton, Ont.; three from the Niagara formation at Barton, Ont., and four from the drift at Winona, Ont.

Lafrance, Mrs., Montcerf, Que.:—

Diatomaceous earth, from a fresh-water deposit 2 miles from Montcerf (near Maniwaki), Ottawa county, Que.

With the diatoms occurs a small proportion of fresh-water sponge spicules.

Foster, Wilson, Dawson, Yukon:—

Molar of *Elephas primigenius*, Blumenbach (Northern Mammoth), from the auriferous gravel, on bed-rock, Eldorado creek, Klondike, 1903.

Malcolm, John, Fergus, Ont.:—

Eleven fossils from the Guelph formation at various localities in Ontario.

Penfold, A., Ottawa East:—

A caudal vertebra of *Delphinapterus leucas*, Pallas, found by Mr. Penfold at Ottawa East, at a depth of 25 feet below the surface, whilst digging a well.

Wilmer, Lieut.-Colonel L. Worthington, Lothian House, Ryde, England:—

Forty-five fossils from the English chalk, and eight other geological specimens therefrom; also two specimens of the living *Purpura lapillus*.

By purchase:—

Four specimens of insects preserved in amber.

A complete skull of the Pleistocene horse (*Equus caballus*, L.), female, from the auriferous gravel, close to bed-rock, at a depth of 35 feet from the surface, on creek placer mining claim, No. 34, Gold-run creek, Yukon.

(B.) ZOOLOGY.

By presentation:—

Garneau, A. L., Ottawa, Ont.:—

A clutch of five eggs of the robin (*Merula migrataria*), taken at Ottawa, May 22.

Young, Reverend Charles J., Madoc, Ont.:—

Seven specimens of the land shell *Patula alternata*, Say, from the shore of Lake Ontario, near Wellington.

Dominion Government Arctic Expedition of 1908-9:—

One pair of horns of musk ox, female.

One specimen of recent marine sponge (Suberites), from Port Leopold, 1907.

A card catalogue of the fossil collections of the Geological Survey was begun on November 12, by Mr. W. J. Wilson, who is assisted in the work by Miss A. E. Wilson.

# PALÆONTOLOGICAL MATERIAL FROM THE DEVONIAN AND CARBONIFEROUS OF SOUTHERN NEW BRUNSWICK.

*(W. J. Wilson.)*

## INTRODUCTION.

In accordance with instructions, the past summer was spent in making a collection of fossil plants from the Devonian and Carboniferous formations of southern New Brunswick—being a continuation of the work begun the preceding year—for the purpose of determining more accurately the boundaries of the formations. The brief study given the collection of 1908 showed that it was desirable to obtain a more complete set of specimens from some of the localities, and to collect from places not examined last year.

In carrying out the work, I am indebted to Dr. Geo. F. Matthew, and Mr. Wm. McIntosh, of St. John; to Hon. James Barnes, president of the Northfield Coal Company, Limited, Minto, Sunbury county; and to Messrs. Meede and Shaw, managers of the Beersville Coal Mines, Kent county, for valuable assistance; also to Mr. W. B. Evans, manager of the Rothwell Coal Company, Limited, Minto, for a splendid collection of fossil plants, which he kindly donated to the Museum.

The following places were visited, and collections made from each: St. John, McCoy head, Gardner creek, Tynemouth creek, Little Lepreau, Moosehorn brook, Cape Enrage, Mary point, Grindstone island; Elgin, Albert county; Minto, Sunbury county; and Beersville, Kent county.

The work done at the localities examined last summer was briefly referred to in the Summary Report for 1908, p. 183. The new places visited this year are: Little Lepreau, Elgin, Minto, and Beersville. It is reported, locally, that many good specimens of fossil plants have been collected from Lepreau; and Bailey and Matthew give a list of about twenty species, named or described by Sir J. W. Dawson, from this locality.[1] As far as I have been able to determine, no plant remains have been collected at Elgin; but in the report for 1876-7, plant stems are mentioned as occurring in the vicinity.[2]

Considerable collections of fossil plants have been made by members of the Geological Survey staff, from the Carboniferous basin in which Minto and Beersville are situated. These fossils were examined and named, or described by Sir J. W. Dawson, who, in 1871, made a list of fifty-five species from Grand lake, Coal creek, Three-tree creek, etc.[3] In 1873, he made an additional list of thirteen species from Salmon river, Cork settlement, Douglas harbour, etc.[4] In the same year he published a 'Report on the Lower Carboniferous and Millstone Grit of Canada,' in which some New Brunswick species are described, and in which is a list of 176 species of 'Plants of the Middle and Upper Coal Formation' of Nova Scotia and New Brunswick; but he does not indicate the species found in the last-named Province. Besides the above, he published many articles on the plants of this region in various scientific publications, and in his Acadian Geology.

1 Geol. Sur. Canada, Report of Progress, 1870-1, p. 177.
2 Geol. Sur. Canada, Report of Progress, 1876-7, p. 374.
3 Geol. Sur. Canada, Report of Progress, 1870-1, pp. 214-216.
4 Geol. Sur. Canada, Report of Progress, 1872-3, pp. 206-207.

Since returning from the field, there has been no opportunity to study the specimens collected. No definite statement can, therefore, be made as to what these fossils will show in regard to fixing the geological boundaries of the two formations under consideration.

*St. John and Vicinity.*—Part of a week was spent, in company with Mr. L. M. Lambe, collecting at the Suspension bridge, Drury cove, and Kennebecasis island. Mr. Lambe has reported on the material collected at the two first mentioned localities. At Duck cove, west of the Fern ledges, a small specimen of *Pseudobaieri McIntoshi* was found.

*Gardner Creek.*—At Gardner creek and McCoy head, a number of species were added to those obtained last year, together with better specimens of others. Many calamites, some of them closely resembling *C. suckovii*; three or four beautiful ferns of sphenopteris type, and slabs almost covered with a fruit like *Cardiocarpum* were secured. A large number of erect calamites were seen in the strata between Doctor brook and Gardner creek. At the mouth of Gardner creek, west side, a fruit of the Antholithes type was found well preserved.

*Tynemouth Creek.*—In 1908, a small collection was made at Tynemouth creek and vicinity, and this summer a more careful examination resulted in a most interesting lot of specimens. The rocks east of Tynemouth creek consist chiefly of reddish sandstone, with occasional grey beds and small layers of fine shale. The finer beds are interlaminated with the coarser all along the shore, and in almost every exposure yield plant remains; numerous pinnules, and small fronds of *Neuropteris, Pecopteris,* and *Alethopteris* were found, also a few *Cordaites* and *Calamites* and many good specimens of fruits. The fruits are well preserved in bright graphite, and seem to be of four species; *Cardiocarpum crampii,* or a closely allied species, being the most numerous. At Regan point, narrow ribbed *Calamites, Alethopteris* leaves, and fronds, numerous well preserved stems and stigmaria with attached rootlets were found.

Just east of Buckley point, a bed of dark, in places almost black, shale, about 16 inches thick, is full of shells of *Naiadites.* Some large slabs are literally covered with these fossils. The bed also holds fish scales, and plant stems; the latter spotted with spirorbis. East of Buckley point, *Calamites, Sigillaria,* and small pinnules of ferns were noted.

*Little Lepreau.*—At Little Lepreau, a small collection of plants was made. In general appearance, the rocks of this locality resemble those at the Fern ledges, St. John, and there are many species of plants recorded as common to both localities. Good specimens of an Alethopteris and an Annularia were got between the mouth of Little Lepreau river and Ragged head. Near Ragged head, on the farms of Dr. Reynolds and Mr. Boyne, specimens of detached *Neuropteris* leaves, showing the venation very clearly, were found; also *Pecopteris* fronds, an *Asterophyllites, Cardiocarpum crampii,* and many *Calamites* and *Cordaites.* At Ragged head there are large trunks of trees, silicified or pyritized.

*Moosehorn Brook, Norton.*—Collections were made from beds near the mouth of Moosehorn brook, and included *Lepidodendron corrugatum* with the leaves attached, small globular bodies, which seem identical with the spore-cases of this plant, as described by Sir J. W. Dawson, from Horton, N.S.;[1] and pinnules of an *Archæopteris* similar to those from Kennebecasis island and Elgin.

*Cape Enrage.*—The coast from Cape Enrage to Mary point was next examined. The rocks north of the lighthouse strike N 34° E, and are nearly vertical, rising sheer out of the water at high tide, forming cliffs over 100 feet high. The rock is mostly

[1] Report on the Fossil Plants of the Lower Carboniferous and Millstone Grit Formations of Canada, p. 20, pl. 2, fig. 22.

grey sandstone, full of coarse plant stems and flattened tree trunks. Interbedded with the sandstone are bands of conglomerate, which are mostly small and not always continuous, and, as everywhere along the coast, there are beds of very fine, friable shale. which weathers easily and leaves the harder rock standing out prominently, as at Squaw Cap. From these shales a good collection was secured, including *Calamites*, ferns, etc.

*Mary Point and Grindstone Island.*—Some interesting fossils were noted at Mary point, where ends of fossil tree trunks show. It is reported that in former years several good ferns were found in the sandstone quarry, but I was only able to secure a few pinnules. A day was spent on Grindstone island, where the rocks are similar to those on Mary point. Only a few plant stems and portions of a tree trunk were found.

*Elgin, Albert County.*—At Elgin, Albert county, part of a week was spent collecting from the shales on Robertson brook. Good specimens of *Lepidodendra;* a pinnule of a fern, like *Archæopteris;* and a large number of fish scales were obtained here.

*Minto, Sunbury County.*—Some of the coal mines at Minto were examined, and collections made from the shale removed with the coal. The best material comes from a very fine-grained, dark grey shale which lies above the coal, and from it a large collection of beautiful specimens was made. Among the specimens were *Lepidodendra* showing the leaf scars perfectly, *Calamites* with leaves attached, and a number of ferns in a very good state of preservation.

In the collection donated by Mr. Evans—referred to on a former page—there is a trunk of a sigillaria, 14 inches long and 12 inches wide; a stigmaria; and several species of ferns, all of which will make good museum specimens.

*Beersville, Kent County.*—At Beersville, a large number of specimens, similar to those at Minto, and occurring under the same conditions, were collected.

## NATURAL HISTORY BRANCH.

*(John Macoun.)*

After the date of my last report, I worked until April 24, on the flora of Vancouver island and that of the Ottawa region: descriptions of both of which are in course of preparation. Office duties have so increased, that the correspondence now takes up a large share of my time and that of my assistant, Mr. J. M. Macoun.

Owing to our success last year in the collecting of natural history specimens in the vicinity of the Biological station at Departure bay, Nanaimo, B.C., and the necessity of collecting further material for the new Museum, the Director deemed it advisable that further collections should be made on Vancouver island. It was decided that Barclay sound and its vicinity was the best location in which to make collections of the marine fauna and flora. Accordingly, Mr. C. H. Young and the writer started for the west on April 24. At Vancouver, Mr. William Spreadborough—who has assisted the writer for many years—was engaged. A house at Ucluelet, on the north side of Barclay sound, kindly placed at our disposal by Mr. Sutton, was occupied during our stay there.

All the members of the party engaged in the collection of specimens: Mr. Spreadborough attended to the preparation of specimens in alcohol and formalin; while Mr. Young prepared the insects, crabs, starfish, etc. As the spring advanced, we extended our collecting grounds, and after the first month dredged in from 5 to 35 fathoms: obtaining a very large series of forms not found at low tide. When the whole of the collections are worked out, it is expected that much light will be thrown on the food of the cod, halibut, and salmon that swarm in these waters.

On August 19, I left by stage for Nanaimo, to visit the Biological station; Messrs. Young, and Spreadborough continuing the work at Ucluelet, until September 1, when we all met again in Victoria. Mr. Young then returned to Ottawa; Mr. Spreadborough completing the unfinished work in the vicinity of Victoria; while I joined the members of the British Association who were visiting the Pacific coast.

Below is given—in general terms—a synopsis of the collections made:—

| | |
|---|---|
| Starfishes | 400 |
| Crabs, and shrimps | 400 |
| Fishes | 100 |
| Isopods | 500 |
| Tunicates, and ascidians | 90 |
| Sponges | 250 |
| Hydrozoa | 150 |
| Jelly fishes | 4 |
| Shells | 37,927 |
| Insects | 850 |
| Birds | 9 |
| Mammals | 2 |
| Toads, etc | 15 |
| Seaworms | 150 |
| Seaurchins | 50 |
| Seaslugs | 75 |
| Barnacles | 35 |

| | |
|---|---|
| Polyzoa | 45 |
| Actinozoa (stony corals) | 25 |
| Sea-spiders | 10 |
| Anemones | 15 |

Of plants, 1,008 species were collected, numbering many thousand specimens. The various families were represented as follows:—

| | |
|---|---|
| Flowering plants | 361 |
| Mosses | 226 |
| Lichens | 123 |
| Liverworts | 134 |
| Seaweeds | 164 |

Since my return from the field, Mr. Young, Mr. J. M. Macoun, and I have been engaged in sorting and naming the specimens collected, when routine work of the office did not otherwise claim our attention. Mr. Young has been working on the insects, and marine material; Mr. J. M. Macoun on birds and flowering plants, and myself on Cryptogams. The fish, decapods, isopods, starfish, and many of the plants, have already been sorted, and a number sent to specialists for confirmation of our determinations.

During the early months of the year much of the time of my assistant—Mr. James M. Macoun—was spent on the Catalogue of Canadian Birds, which is now published, and being distributed. Good progress was also made in the re-arrangement of the herbarium; in the distribution of specimens, and in the naming and mounting of botanical material. In the herbarium, 2,171 sheets of specimens have been placed; and 3,272 sheets distributed to museums and colleges. No record of the number of specimens named for correspondents was kept until the autumn of 1909; but 648 sheets have been so named since September 23, and 554 letters were written in connexion with our work. Besides her usual work as stenographer, Miss M. C. Stewart has done most of the labelling, and as time permitted, assisted in other ways in all branches of our work.

The Natural History specimens which have been acquired by purchase or otherwise since the death of Dr. Whiteaves, are:—

By presentation—

Saunders, W. E., London, Ont.:—

Two females of Mole (*Scalops aquaticus*)—Point Pelee, Ont.

Thirteen specimens of White-footed Mouse: four species; two males of *Peromyscus Bairdii*; two females and one male of *P. Americanus*; two males and one female of *P. Canadensis*; and four females and one male of *P. Michiganensis*, all from Point Pelee, Ont.

One Cardinal Bird—Point Pelee, Ont.

One Carolina Wren—Point Pelee, Ont.

Leach, W. W., Geological Survey, Ottawa:—

Skull of Lemming *(Lemmus helvolus)*, from head of Telkwa river, B.C., July, 1909.

Venner, Walter, Quebec, Que.:—

Brown Bat (*Vespertilio fuscus*), Parliament Buildings, Ottawa, February 24, 1909.

Bernier, Capt., Quebec, Que.

Barren Ground Caribou (*Rangifer arcticus*), Melville island.
Musk Ox (*Ovibos moschatus*), six skulls, Melville island.

MacMillan, G. R.:—

Skins of Great Northern Diver, White Gyrfalcon, and Snowy Owl; sex unknown; Melville island.

Questin, A. R., Carcross, Yukon:—

Male, female, and young of Dall's Mountain Sheep (*Ovis dalli*), Yukon mountains.

Porter, H. E., Whitehorse, Yukon:—

Male, female, and young of Moose (*Alce gigas*), from near Whitehorse.

Slack, J. H., Ottawa, Ont.:—

Gannet (*Sula bassana*): a young bird killed in October at Britannia, Ont.

## MAPPING AND ENGRAVING.

*(C. Omer Senécal.)*

In April and May last, by request of the Director, competitive examinations for draughtsmen were held by the Civil Service Commission: Mr. James White, then Chief Geographer of the Department of the Interior, and the writer, acting as technical examiners. The best two draughtsmen were selected by the Commission, and appointed on the staff of the Geological Survey.

The personnel of this division at present consists of eleven members: namely, Messrs. G. C. Aitken, A. Dickison, J. O. Fortin, S. Jost, J. F. E. Johnston, H. Lefebvre, F. O'Farrell, O. E. Prud'homme, J. A. Robert, R. B. Yorston, and J. J. McGee.

The routine work includes the plotting of geographical projections; computation of astronomical observations; compilation of all kinds of maps, and the drawing and preparation of the same for engraving and publication; correction and revision of map proofs; making photographic reductions of maps, negatives, and prints; tracings and drawings of all descriptions for office and field use and general geographical work. Some 300 letters, memoranda, specification sheets, reports, etc., relating to the work of the division were sent out, while 260 were received.

### Map Editions Published.

There are at present seven maps in the hands of the King's Printer, several of which will be issued shortly. A list of the editions received during the year 1909, is given below:—

1042 Dominion of Canada—Minerals—Scale 100 miles to 1 inch—Second edition.
1084 Dominion of Canada—Geology—Scale 100 miles to 1 inch.
1083 Western Canada—Geology—Scale 100 miles to 1 inch—Special edition, not intended for general distribution.
1041 Yukon Territory—Whitehorse Copper Belt—Geology—Scale 1 mile to 1 inch.
1026 Yukon Territory—Whitehorse Copper Belt—Geology of central portion—Scale 400 feet to 1 inch.
1044 Yukon Territory—Whitehorse Copper Belt—Surface at Arctic Chief mine—Scale 160 feet to 1 inch.
1045 Yukon Territory—Whitehorse Copper Belt—Grafter mine—Scale 20 feet to 1 inch.
1046 Yukon Territory—Whitehorse Copper Belt—Empress of India mineral claim—Scale 200 feet to 1 inch.
1047 Yukon Territory—Whitehorse Copper Belt—Surface at Copper King mine—Scale 400 feet to 1 inch.
1048 Yukon Territory—Whitehorse Copper Belt—Best Chance ore body—Scale 40 feet to 1 inch.
1049 Yukon Territory—Whitehorse Copper Belt—Surface at Pueblo mine—Scale 60 feet to 1 inch.
1002 British Columbia—Special map of Rossland, West Kootenay—Geological sheet—Scale 400 feet to 1 inch.
1004 British Columbia—Rossland Mining camp, West Kootenay—Geological sheet—Scale 1200 feet to 1 inch.

1074 British Columbia—Sheep Creek Mining camp, West Kootenay—Sketch topographical map—Scale 1 mile to 1 inch.

993 Northwestern Ontario—Explored routes between Lake Nipigon and Sturgeon lake—Scale 4 miles to 1 inch.

1061 Northwestern Ontario—Explored routes between Lake Minnitaki and Lake of the Woods—Scale 4 miles to 1 inch.

1023 Central Ontario—General geological map showing Corundum-bearing rocks—Scale about 18 miles to 1 inch.

1076 Northern Ontario—Gowganda Mining Division—District of Nipissing—Preliminary geological edition—Scale 1 mile to 1 inch.

1019 Nova Scotia—City of Halifax geological sheet, No. 68—Scale 1 mile to 1 inch.

1019a Nova Scotia—City of Halifax and vicinity—uncoloured—Scale 1 mile to 1 inch.

1025 Nova Scotia—Waverley geological sheet, No. 67, Halifax and Hants counties—Scale 1 mile to 1 inch.

1037 Nova Scotia—Windsor geological sheet, No. 73, Hants county—Scale 1 mile to 1 inch.

—— Nova Scotia—Ponhook Lake sheet, No. 72—Temporary edition, uncoloured—Scale 1 mile to 1 inch.

## LIBRARY.

*(Jane Alexander, Acting Librarian.)*

Publications, to the number of 2,901, were received during the calendar year, as gifts or exchanges: including—besides periodicals—maps, reports, and publications of foreign Geological Surveys, together with memoirs, transactions, and proceedings of scientific societies of both Europe and America.

The number of volumes purchased was 99—costing $369.05; and 85 periodicals were subscribed for; while 325 volumes were bound.

Letters sent out relating to library work numbered 164; while 710 replies were received acknowledging the receipt of Geological Survey publications.

Bsides cataloguing current additions to the Library, more than 3,000 index cards have been re-written, filled up to date, and placed in the new catalogue drawers.

## PUBLICATIONS.

**The following Reports and Catalogues have been Published since January 1, 1909:—**

No.

973 Catalogue of Canadian Birds. By J. Macoun. Published December 15, 1909.

980 Report on a Portion of Northwestern Ontario, in the Districts of Algoma and Thunder Bay. By W. J. Wilson. (Bound with No. 1081.) Published November 8, 1909.

996 Preliminary Report on a Portion of the Main Coast of British Columbia and Adjacent Islands (Second edition). By O. E. LeRoy. Published July 19, 1909.

1020 Contributions to Canadian Palæontology, Volume III (quarto), Part IV: The Vertebrata of the Oligocene of the Cypress Hills, Saskatchewan. By L. M. Lambe. Published March 26, 1909.

1035 Report on Coal Fields of Manitoba, Alberta, Saskatchewan, and Eastern British Columbia. By D. B. Dowling. Published October 15, 1909.

1050 Report on Whitehorse Copper Belt, Yukon. By R. G. McConnell. Published October 4, 1909.

1052 Report on Artesian Wells in the Island of Montreal. By F. D. Adams and O. E. LeRoy. *French translation.* Published October 28, 1909.

1072 Summary Report, 1908. Published May 4, 1909.

1073 Catalogue of Publications (1843-1909). Published October 4, 1909.

1075 Preliminary Report on Gowganda Mining Division, District of Nipissing, Ont. By W. H. Collins. Published May 22, 1909.

1081 Report on the Region lying North of Lake Superior, between the Pic and Nipigon Rivers, Ontario. By W. H. Collins. (Bound with No. 980.) Published November 8, 1909.

1085 A Descriptive Sketch of the Geology and Economic Minerals of Canada. By G. A. Young—with Introduction by R. W. Brock. Published November 2, 1909.

### SPECIAL REPRINTS.

The Nepheline and Associated Alkali Syenites of Eastern Ontario. By Frank D. Adams and Alfred E. Barlow. Transactions of the Royal Society of Canada, Volume II, Section IV. Published August 14, 1909.

FRENCH TRANSLATIONS.

*(M. Sauvalle.)*

949a Report on the Cascade Coal Basin, Alberta. By D. B. Dowling. (Sess. Paper No. 26 C.) (Edited only.)

999 Preliminary Report on Gowganda Mining Division, District of Nipissing, Ont. By W. H. Collins.

1035a The Coal Fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia. By D. B. Dowling.

1067 Report on the Geology and Physical Character of the Nastapoka Islands, Hudson Bay. By A. P. Low.

1114 Report on the Algoma and Thunder Bay Districts. By W. J. Wilson. (Bound with No. 1119.)

1119 Report on the Region lying North of Lake Superior, between the Pic and Nipigon Rivers. By W. H. Collins. (Bound with No. 1114.)

1124 Report on the Dominion Government Expedition to Hudson Bay and Arctic Islands. By A. P. Low.

## DISTRIBUTION OF PUBLICATIONS.

During the past year, 76,681 publications—including reports, parts of reports, bulletins, maps, etc.—were distributed to libraries, scientific institutions, exchanges, and individual applicants: of these, 42,835 were distributed in Canada; 8,820 in the United States; 8,201 in England, and 11,825 in foreign countries.

The sale of publications during the year—December 1, 1908, to December 31, 1909—including maps and reports, amounted to $405.19.

The number of letters received in connexion with the distribution of maps and reports, was 5,174; besides 10,800 acknowledgments from exchanges and individuals. The number of letters sent out was 3,242.

## ACCOUNTANT'S STATEMENT.

The staff of the Geological Survey, at present employed, numbers 70. During the calendar year the following changes in the staff have taken place:—

Deaths:—

J. F. Whiteaves.
Hugh Fletcher.

Appointments:—

A. S. Jost.
J. O. Fortin.
J. A. Dresser.
W. Malcolm.
M. Calhoun.

The funds available for the work and expenditure of the Geological Survey for the fiscal year ending March 31, 1909, were:—

| Details. | Grant. | Expenditure. |
|---|---|---|
| Appropriations | $281,877 33 | |
| Civil-list salaries | ...... | $91,383 59 |
| Explorations and surveys | ...... | 58,678 60 |
| Experimental borings for gas, oil, etc. | ...... | 14,656 65 |
| Wages of temporary employes | ...... | 21,778 51 |
| Printing, engraving, and lithographing | ...... | 42,559 43 |
| Books and instruments | ...... | 6,888 39 |
| Chemicals and apparatus | ...... | 22 81 |
| Specimens for Museum | ...... | 6,520 92 |
| Stationery, mapping materials, etc. | ...... | 5,116 30 |
| Ottawa Exhibition, 1908 | ...... | 96 46 |
| Incidental and other expenses | ...... | 7,288 32 |
| Unexpended balance | ...... | 27,464 70 |
| | | $282,454 68 |
| Less—Paid from appropriations 1907-8 | ...... | 577 35 |
| | $281,877 33 | $281,877 33 |

(Signed) JNO. MARSHALL,
*Accountant, Department of Mines.*

## GENERAL CONCLUSIONS.

A review of the foregoing reports will give point to the statement made in the introductory, that the work undertaken by the Survey is essentially practical and economic in character. While the needs of the miner and prospector must receive our chief consideration—since mining now ranks second only to agriculture among the national industries, and since intelligent and efficient mining must have as a foundation a sound knowledge of the geological conditions—still it has not been forgotten that it is the duty of the Survey, as a public institution, to collect and disseminate information of interest and value to the public in general.

The fields selected for investigation have been, almost without exception, those for which there has been a strongly expressed popular demand. On account of the limited staff, however, many areas that should have received attention have, perforce, been neglected.

To strengthen the field corps—especially in those cases where a specialist was required—I have not hesitated to enlist the services of foreign experts. This procedure has been justified by the results of the various investigations.

I have the honour to be, Sir,

Your obedient servant,

(Signed) R. W. BROCK.

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